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Report 177

Geology of

Honeywell and McNaughton Townships

District of Kenora (Patricia Portion)

By

G.W. Johns

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GEOLOGICAL MAP

(back pocket)

Map 2404 (coloured)–Honeywell and McNaughton Townships,
District of Kenora (Patricia Portion).
Scale 1:31 680 (1 inch to ½ mile)

ABSTRACT

This report describes the geology of Honeywell and McNaughton Townships which are located 90 km east-northeast of the town of Red Lake in the District of Kenora, Patricia Portion. The rocks in the map-area are Early Precambrian (Archean) in age, and are located within the southeastern part of the Birch-Uchi Lakes Metavolcanic-Metasedimentary Belt.

Within the map-area, nine metavolcanic formations in four volcanic cycles, three major metasedimentary formations, and two granitic plutons have been recognized. Mafic volcanic rocks are found in five formations consisting of massive and porphyritic flows, some of which exhibit pillows, pillow-breccia, and flow-top breccia.

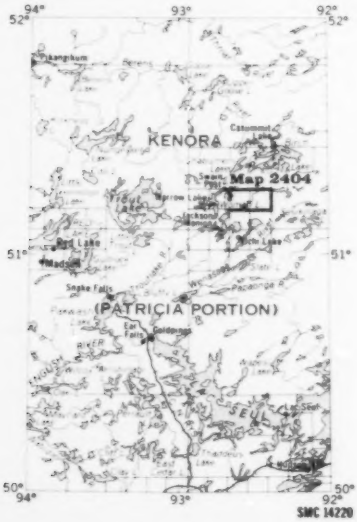

Figure 1–Key map showing location of Honeywell and McNaughton Townships. Scale 1:3 168 000 (1 inch to 50 miles).

Intermediate and felsic metavolcanics occur in four formations predominantly comprising tuff, lapilli-tuff, and spherulitic flows, with the minor occurrence of pyroclastic breccia and tuff-breccia.

The metasediments are primarily wacke, conglomerate, slate, argillite, and arenite. A thin band of jasper iron formation extends 3000 m north in Honeywell Township. The metavolcanic-metasedimentary formations have been extensively intruded by concordant to discordant gabbro sills and thin quartz-feldspar and feldspar porphyry sills. The two granitic plutons cut all the previous rock types, are inhomogeneous, and consist of phases ranging in composition from syenodiorite to granodiorite.

The Birch-Uchi Lakes Metavolcanic-Metasedimentary Belt is isoclinally folded about a north-trending axial trace of a syncline which crosses Washagomis Lake, then curves to the northeast. The strata in the map-area mainly lie on the eastern limb of the syncline, and face west except in the central part where some opposing tops indicate the possibility of further folding. The formations strike approximately north in the southern part of the map-area, and trend northeast in the northern part.

There are two predominant fault sets, one strikes northeast ,and the other strikes southeast. With the exception of two southeast-trending faults in the vicinity of Grace Lake in Honeywell Township, there appears to be no significant horizontal displacement on the faults.

Honeywell and McNaughton Townships were subjected to staking rushes during 1926 to 1927, and 1969 to 1970 for gold and base metals.

The potential for finding mineral deposits in the map-area is high. A major lineament can be traced between Washagomis Lake and the western arm of Grace Lake. Gold has been found on ground close to this lineament in the regions west of the map-area. Therefore this lineament could indicate the potential for vein-type gold deposits. The coarse-grained felsic pyroclastics in the north-eastern corner of Honeywell Township are favourable horizons for syngenetic massive sulphide deposits, and should be prospected for this type of mineralization.

Geology of
Honeywell and McNaughton Townships
District of Kenora, Patricia Portion

by

G.W. Johns[1]

INTRODUCTION

The centre of the map-area is located 90 km east-northeast of the town of Red Lake in the District of Kenora, Patricia Portion, and is in the Red Lake Mining Division. The area covers 190 km^2 and comprises the townships of Honeywell and McNaughton.

The map-area lies within the southeastern part of the Birch-Uchi Lakes Metavolcanic-Metasedimentary Belt, in the Uchi Subprovince (Ayres *et al.* 1971). Gold, and more recently, base-metals have been the major materials of economic interest in the area.

Access

The map-area can be reached from Red Lake and Ear Falls by means of float-equipped aircraft. All major lakes in the area are accessible to float-equipped aircraft. McNaughton Lake has a brownish red colour, and a visibility through the water that is less than 0.3 m. There are reefs in the lake, particularly between the two islands at the eastern end of the lake and the southwestern shore. Aircraft landings should be undertaken with extreme caution. Washagomis Lake, in the western part of Honeywell Township, can be reached from Confederation Lake via the Woman River, by using three short portages which are in an excellent condition. Washagomis Lake can also be reached without any portages from the northern end of Woman Lake via the Woman River and Swain Lake. Woman Lake and Confederation Lake are accessible from the South Bay Mine Road. Grace Lake, in the north-central part of the map-area, may be reached by three portages, which are in an unknown condition, from the eastern end of Swain Lake; the longest is 680 m. In the spring, it should be possi-

[1]Geologist, Precambrian Section, Ontario Geological Survey.
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ble to reach Okanse Lake from the southern end of the east bay of Grace Lake by means of three portages which are in fair condition, and by using the Okanse River.

Numerous lakes including Okanse, Sundown, Honeywell, Washagomis, Swain, Grace, McNaughton, and Cook Lakes provided easy mobility by motorized canoe. Parts of the Okanse River may be used during high water to reach the southwestern and north-central parts of McNaughton Township.

Previous Geological Investigations

The region around Honeywell and McNaughton Townships has been the subject of various reconnaissance geological surveys. In 1919, E.M. Burwash mapped the major water routes between Trout Lake, Birch-Springpole Lakes, and Lac Seul (Burwash 1920). J.W. Greig, in 1926, outlined the distribution of metavolcanics, metasediments, and granitic rocks in the Woman and Narrow Lakes area, which included Honeywell and McNaughton Townships (Greig 1927). In 1932, G.D. Furse mapped a region immediately to the north of Honeywell and McNaughton Townships (Furse 1933); W.D. Harding's map-area of 1935 included this region (Harding 1936). More recent detailed mapping in the Birch-Uchi Lakes Metavolcanic-Metasedimentary Belt has been carried out by P.C. Thurston *et al.* (1975a,b, and c) and A.P. Pryslak (1970a and b; 1971a and b; 1972; 1973; and 1974).

Present Geological Investigation

Field work was conducted between May 28 and September 6, 1975. During the initial part of the season, and intermittently during the season, P.C. Thurston (Subsection Leader, Precambrian Geology Section, Ontario Geological Survey) directed the field operation, advised the author, and mapped parts of the area in conjunction with the author. The field map was prepared at a scale of 1:15 840 (1 inch to ¼ mile) on cronaflex base maps prepared by the Cartography Section, Surveys and Mapping Branch, Division of Lands, and from maps of the Forestry Resources Inventory, Division of Forests, Ontario Ministry of Natural Resources. The field data were plotted on acetate overlays to aerial photographs of the same scale as the base maps. Because of the high density of outcrops and the complex nature of the geology, the traverses were planned to examine as many outcrops as possible. Large outcrops and topographic features visible on aerial photographs were used as control points.

Acknowledgments

The author is indebted to P.C. Thurston for his direction, advice, and mapping assistance in the field, and for the benefit derived from his experience in the

Confederation Lake area (Thurston *et al.* 1975a,b and c) and the many useful discussions held with him during report preparation. The author was assisted by R.M. Falls, C.R. Ware, Susan Savory, Herbert Christmann, and D.A. Smith. Mr. R.M. Falls conducted independent mapping throughout the season and some independent mapping was done by C.R. Ware.

The author would like to thank Wayne Valliant (Resident Geologist's Office, Ontario Ministry of Natural Resources, Red Lake) for his assistance in providing logistical support throughout the summer.

Prospecting and Mining Activity

Prior to the Red Lake gold rush in 1925, little was known about the region surrounding the map-area. By 1926, the prospecting activity that was focused on Red Lake moved to the Birch-Uchi Lakes Metavolcanic-Metasedimentary Belt. As a result of this activity, the Sol d' Or Gold Mine was discovered. Owing to the financial slump of 1929, activity in the area was curtailed.

Activity was resumed in 1969 after the discovery of base-metal mineralization in Dent Township by Selco Mining Corporation Limited. All available ground in Honeywell Township was then acquired, flown by airborne geophysical surveys, and subjected in most cases to follow-up ground geophysical programmes in the search for base metals by numerous companies. More recent work has been done by Ronda Copper Mines Limited and St. Joseph Explorations Limited. McIntyre Mines Limited carried out exploration in Honeywell Township during 1975.

Topography and Drainage

The mean elevation of the map-area is 425 m above sea level. The relief is gentle throughout the area; the highest hill is located on the western shore of Sundown Lake, rising approximately 60 m above the lake. The lakes within the area, except Washagomis Lake, occupy erosional basins in the glacial deposits. The streams within McNaughton Township are oriented parallel to the bedding in the underlying bedrock. All the lakes in the area drain north into the Cat River and Lake St. Joseph. The only exception to this is Cook Lake in the southeastern corner of McNaughton Township. This lake drains south into the Lac Seul-English River system.

The ground moraine in Honeywell Township is, for the most part, thin, and allows excellent exposure of the bedrock. The drift cover thickens to the east, and exposure in McNaughton Township is fair to poor. The overburden consists primarily of boulder till; clean well-sorted sand occurs southeast of Cook Lake, and also in an area north of McNaughton Lake, south of the Okanse River. In Honeywell Township, swamps are of minor importance. McNaughton Township has lower relief and poorer drainage than Honeywell Township, and the resulting swamps and muskeg areas make traversing difficult.

Natural Resources

The lakes in the area contain northern pike, yellow pickerel, and less commonly, gray trout. Tourist Lodges in Ear Falls and Vermilion Bay have outpost camps on Okanse Lake, Swain Lake, and Grace Lake.

The map-area is in the northern coniferous section of the Boreal Forest Region (Rowe 1959). Black spruce is the predominant tree, and is associated with jack pine which is more predominant in forested areas burnt several decades ago. White birch is widespread in the well-drained parts of old burned areas. Balsam fir and poplar (aspen) are also common throughout the area.

There are no permanent residents in the area.

GENERAL GEOLOGY

The map-area lies in the southeastern part of the Early Precambrian, Birch-Uchi Lakes Metavolcanic-Metasedimentary Belt, within the Uchi Lake Subprovince (Ayres *et al.* 1971). The belt strikes north in the southern part of the area, and swings to the northeast in the northern part. In the map-area, the Birch-Uchi Lakes Metavolcanic-Metasedimentary Belt has been intruded by the Okanse Lake Pluton and the Cook Lake Pluton. The sequence has the following lithologic composition: 33 percent mafic flows, 24 percent intermediate pyroclastics and flows, 2 percent felsic pyroclastics, 7 percent metagabbro intrusions, and 34 percent metasediments consisting predominantly of greywacke, conglomerate, and arkose. Minor metasedimentary units include argillite, siltstone, oxide iron formation, and sulphide iron formation. The metasediments, east of the main volcanic sequence, have been defined by J.D. Bateman (1939) as the Slate Lake Series. The metavolcanics in the map-area have been re-defined by A.M. Goodwin (1967, p.10) as the Uchi Series.

Stratigraphy within the map area is straight forward, and nine metavolcanic formations have been recognized. The sequence is characterized by minor lateral and vertical facies changes, and most formations can be traced across the map-area, a distance of 10 km. The formations have not been given formal or informal designations because: (1) the map-area is only a small part of the larger Birch-Uchi Lakes Metavolcanic-Metasedimentary Belt; (2) the Okanse Lake Pluton makes correlation with the geology to the south difficult; and (3) not enough is known, at present, about the geology to the north with respect to continuity of the proposed units.

The metavolcanic sequence represents parts of four cycles[1] of volcanism that, in general, started with effusive mafic volcanism and culminated with explosive intermediate to felsic volcanism. Volcanic Cycle One, the lowest cycle, and the most structurally complex, is composed of two mafic units and two intermediate to felsic units. Volcanic Cycle Two represents a mafic metavolcanic unit that thickens to the north, and an overlying intermediate metavolcanic unit that thins to the north. Volcanic Cycle Three, consists of two mafic units one thickening to the north, with an intervening intermediate unit thinning to the north. These cycles include conglomerate lenses, thin greywacke and argillite beds, and thin iron formation.

[1]Subsequent work (Thurston *et al.* 1978) indicates that the Fourth Volcanic Cycle is in fact part of Volcanic Cycle Three.

TABLE 1 TABLE OF LITHOLOGIC UNITS FOR HONEYWELL AND McNAUGHTON TOWNSHIPS.

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT

Swamp, stream, and lacustrine deposits

PLEISTOCENE

Till, clay, sand, and gravel

UNCONFORMITY

PRECAMBRIAN

EARLY PRECAMBRIAN

FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

Hornblende and biotite diorite, syenodiorite, hornblende and biotite trondhjemite, quartz diroite, hornblende and biotite quartz monzonite to granodiorite, and pink pegmatite

Intrusive Contact

METAMORPHOSED FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

Quartz-feldspar porphyry, feldspar porphyry, mafic feldspar porphyry, and felsite

Intrusive Contact

METAMORPHOSED MAFIC and ULTRAMAFIC ROCKS

Gabbro, diorite, quartz diorite, quartz gabbro, porphyritic gabbro, serpentinized peridotite, serpentinized dunite, and pyroxenite

Intrusive Contact

METASEDIMENTS

CHEMICAL METASEDIMENTS

Oxide- and sulphide-facies iron formation

CLASTIC METASEDIMENTS

Wacke, slate, argillite, arenite, arkose, conglomerate, reworked tuff, siltstone, quartz-wacke, quartz arenite

METAVOLCANICS

FELSIC METAVOLCANICS

Flow tuff, lapilistone, lapilli-tuff, tuff-breccia, thin bedded flow

INTERMEDIATE METAVOLCANICS

Flow tuff, pyroclastic breccia, lapilli-tuff, tuff-breccia, spherulitic flow, amygdaloidal and porphyritic flow, autoclastic breccia, flow layered flow

MAFIC METAVOLCANICS

Porphyritic, glomeroporphyritic, amygdaloidal, massive, and pillowed flows with pillow breccia and coarse-grained centres; pyroclastic rock, autoclastic breccia, variolitic flow, hyaloclatic breccia, hyaloclastite, carbonatized flow, lapilli-tuff

Prior to major metamorphism, and possibly during volcanism, the volcanic-sedimentary sequence was intruded by gabbroic and dioritic dikes and sills as well as some sills of intermediate to felsic porphyritic rocks. These early intrusions have been metamorphosed. Late felsic igneous activity resulted in the emplacement of the Okanse Lake and Cook Lake Plutons.

The volcanic-sedimentary-gabbroic sequence was regionally metamorphosed under greenschist facies conditions. Hornblende-hornfels facies (Winkler 1967) contact metamorphism was recognized by members of the field party immediately adjacent to the late felsic plutons.

The map-area is now largely covered by glacial deposits consisting primarily of ground moraine and some clean well sorted sand plains in the northern and southern part of McNaughton Township. The ground moraine cover is thick in parts of the map area, and contributes to the swampy conditions which are common between outcrop regions.

Precambrian

EARLY PRECAMBRIAN (ARCHEAN)

Metavolcanic-Metasedimentary Sequence

METAVOLCANICS

The metavolcanics, including those of pyroclastic origin, form approximately 50 percent of the rock in the map-area. A three-fold classification, based on colour index, was used to describe the rock. Colour index is the percentage of mafic minerals such as amphibole, biotite, and chlorite in the rock, and can be determined by observing with a good hand lens, the weathered rind of the sample. As classified in this report, mafic metavolcanics have a colour index greater than 35, the intermediate metavolcanics have a colour index between 35 and 15, and the felsic metavolcanics have a colour index of less than 15. Based on stratigraphic sections, the relative abundance of the three groups in the metavolcanic sequence are; mafic metavolcanics 54 percent, intermediate metavolcanics 42 percent, and felsic metavolcanics 4 percent.

The metavolcanics have undergone regional metamorphism of greenschist facies rank. In the vicinity of the Okanse Lake Pluton the rocks have been metamorphosed to hornblende hornfels facies rank.

Mafic Metavolcanics

The mafic metavolcanics occur in five linear units. Minor mafic flows are also found throughout the area, intercalated with the intermediate metavolcanics

and the metasediments. The thickness of individual flows was not discernable because flow to flow contacts were not observed due to extensive lichen and moss cover inhibiting outcrop examination. Goodwin (1967, p.12) reported that the flows (in the Uchi Series) average 3 to 15 m thick and are as much as 30 m thick. The appearance of the mafic flows is not the same throughout the area.

From east to west, the first two linear units of mafic metavolcanics are considered by the author to comprise the base of Volcanic Cycle One, the oldest volcanic cycle in the map-area. The most easterly part of the mafic unit, which bisects the metasediments in McNaughton Township, maintains a relatively constant thickness of 900 m over its length within the map-area. The other part of this mafic unit occurs along the Honeywell-McNaughton township boundary as a discontinuous linear unit cut by gabbroic sills. The width of this unit varies between 1500 m in the south, 600 m in the central part, and 1200 m in the northern part of the area, over a distance of 4700 m.

That part of the mafic unit lying wholly in McNaughton Township has a uniform massive appearance. The outcrops generally have a homogeneous grey weathered surface with a fine-grained, dark green, fresh surface. Foliation formed by a preferential orientation of plagioclase, chlorite, and amphibole, has a near vertical dip. Poorly defined pillows occur randomly throughout this unit and broken pillow-breccia (Carlisle 1963) is rarely found.

Pillow-breccia, where it occurs, consists of circular to elliptical fragments of similar composition that range in size from 1 to 15 cm and are scattered throughout the outcrop. Cooling selvages around the fragments are about 1 mm thick. The matrix is vesicular in places and appears to be more felsic than the fragments.

Southeast of Wagner Lake, a bifurcating mafic dikelet cuts pillow-breccia and a quartz vein. This dikelet is similar in appearance and probably in composition to the pillow-breccia, and was emplaced shortly after the formation of the pillow-breccia when the interior of the flow was still molten. The quartz veinlet was probably formed by degassing of the mafic flow. The dikelet exhibits a thin, chilled margin. Quartz veins averaging 15 cm in width are common throughout the metavolcanic flows, within this part of the unit.

The part of this mafic unit centred about the Honeywell-McNaughton Township boundary appears to have been deposited in an environment differing from that in which the previously described part was deposited. A shallow water environment is suggested by the presence of amygdules, abundant pillow breccia, and flow-top breccia throughout this unit, and the intercalation with intermediate pyroclastic rocks in the south. Parts of the flows have coarse-grained, almost gabbroic centres, and amphibole and feldspar phenocrysts have also developed.

Between the two bays on the eastern shore of Okanse Lake, two outcrops of mafic flows have xenoliths 1.5 m by 0.75 m that are composed of felsic tuff having 2.5 to 7.5 cm thick beds.

The appearance of the mafic flows changes as the Okanse Lake Pluton is approached, and the metamorphic grade increases from greenschist to hornblende hornfels facies. Stringers and blebs of granitic material are found in the outcrops nearest the pluton. The outcrops in the northern part of the unit have a buff to grey weathered surface which is typical of the greenschist facies. These outcrops are also fine to coarse grained with dark green fresh surfaces. The weathered and

fresh surfaces darken toward the Okanse Lake Pluton. Recrystallization and alteration of the clasts of the pillow-breccia units to epidote is prominent just east of Okanse Lake. Hornblende, which is altered to chlorite, comprises approximately 60 percent of a holocrystalline medium-grained subophitic mafic flow found just north of the eastern end of Okanse Lake. Albite to andesine phenocrysts that have been altered to epidote have also been partly replaced by quartz.

The third linear unit of mafic flows is the basal unit of Volcanic Cycle Two. It extends from just north of Okanse Lake, along the eastern shore of Honeywell Lake, through Bamford Lake, and across the northern boundary of Honeywell Township, a distance of 7300 m. The apparent thickness of this unit increases from 1500 m south of Honeywell Lake to 2100 m north of Honeywell Lake.

That part of the mafic unit that lies north of the long arm of Honeywell Lake and west of the iron formation has been altered, and plagioclase has been extensively saussuritized. The outcrops have a white- to buff-weathered surface and a pale green fresh surface. Thin section examination of the saussuritized basalts indicates that plagioclase is altered to epidote, sericite, and carbonate. The groundmass is also predominantly composed of epidote and chlorite with some tremolite pseudomorphic after pyroxene. That part of the unit occurring east of the iron formation is darker and contains less saussurite than the lighter coloured mafic flows.

Well-formed pillows found north of Bamford Lake have a 2:1 length to width ratio. These pillows also have calcite-filled amygdules averaging 8 mm in diameter in the centre of the pillow and a rim, 1 cm wide, of amygdules 1 mm in size around the edge of the pillows. Selvages are 1.4 to 2 cm thick. Massive flows predominate in the north, pillow lava and pillow-breccia occur at Bamford Lake, and all three types occur south of Honeywell Lake.

South of the long arm of Honeywell Lake, the top third of the mafic unit consists of coarse-grained flows, as well as some areas of glomeroporphyritic flows which occur 450 m below the overlying intermediate unit. The glomeroporphyritic flows consist of feldspar clots averaging 5 cm in diameter and form 85 to 90 percent of the rock.

A coarse-grained porphyritic part of the mafic unit outcrops at the junction of the main part of Honeywell Lake and its long eastern arm. The feldspar phenocrysts are euhedral, and are 5 to 8 mm by 2 to 3 mm in size, composing 40 to 50 percent of the rock. The coarse-grained flows are found roughly in the centre of the mafic unit which outcrops from Honeywell Lake northwards to the lake that is due west of Grace Lake. These coarse-grained flows closely resemble gabbros, but were classified as flows for two reasons: 1) their close relationship to iron formation; and (2) the lack of cross-cutting relationships with the surrounding flows. The pillow-breccia in the unit consists of unsorted angular to subrounded fragments, some of which exhibit amygdules and pillow selvages. Outcrops of flow-top breccia (autoclastic breccia) and porphyritic flows are found scattered throughout the unit.

The fourth linear unit of mafic metavolcanics forming the base of Volcanic Cycle Three extends north from the western end of Okanse Lake, along the western shore of Honeywell Lake, and through the cluster of little lakes on the northern boundary of Honeywell Township. The mafic unit widens from 1200 m in the south to 2000 m in the north. The unit mainly consists of saussuritized ba-

salt identical to those described previously. The weathered surface is pale buff to buff, and the fresh surface is pale green with a white-weathered rind. The hardness varies, but tends to be around the hardness of a knife. The nature of these saussuritized flows has mislead some workers into believing that they were felsic metavolcanic flows (Resident Geologist's Files, Ontario Ministry of Natural Resources, Red Lake).

Primary structures such as, pillows, amygdules, and flow-top breccia are well preserved; flow-top breccia is not extensive, and is not shown on Map 2404, back pocket. Pillow-breccia, which is prominent in the previously described mafic units, is absent in this linear belt, except for one or two outcrops in the north. The flows are intercalated with intermediate tuffs in the southern part of this mafic unit. Intermediate tuff was found incorporated as xenoliths in the base of a mafic flow.

The saussuritization of the mafic flows decreases to the south, and the epidote alteration appears as blebs and stringers throughout the outcrops. The stringers trend across the foliation. The unaltered mafic flows are dark green on the fresh surface, and the major mafic mineral is fibrous amphibole. Primary textures and structures were rarely observed other than in thin section, but where observed, consist of variolites, flow banding, and diabasic texture.

Flows recrystallized by contact metamorphism near the Okanse Lake Pluton consist of greater than 60 percent coarse-grained amphibole and untwinned feldspar. A chemical analysis (Table 2, Sample 75-2-59) of an outcrop in this region indicated that the rock was a high-magnesium basalt.

The fifth linear unit of mafic metavolcanics lies at the extreme western end of the map-area, and extends north-south over the length of Honeywell Township. Its true thickness is not apparent as the top of the unit was not observed. This unit has the most uniform appearance of all the linear mafic units previously described in this section. The outcrops have a light buff-brown weathered surface, and a light green fresh surface. The weathered rind, for the most part, is white to cream, and the mafic minerals are not readily apparent.

Pillows, amygdules, flow-top breccia, and phenocrysts, common throughout the unit, are well preserved, and may be seen in detail along the shore of Washagomis Lake. Top determinations were made from well-formed pillows around Washagomis Lake and to the north-northeast. Amygdules in pillows, pillow selvages, and massive flows are spherical, 1 to 3 mm in diameter, and are filled with carbonate and quartz. Pillow-breccia is common, and consists of unsorted, ellipsoidal, subrounded fragments in a fine-grained matrix. The fragment to matrix ratio is greater for the hyaloclastites in this fifth linear unit, than those in the other mafic units in the part of the volcanic pile mapped. The porphyritic parts of the flows consist of 5 to 15 percent euhedral plagioclase phenocrysts. Certain distinct porphyritic horizons were noted in various outcrops along strike, but were never traced very far. The microscopic appearance of the saussuritized mafic flows has been described previously.

Chemical analyses indicate that the rocks in all the mafic linear units range from silica deficient basalt to andesite (Table 2). Two samples have a high-magnesia content relative to average tholeiitic basalt (Viljoen and Viljoen 1969). Thin section data reveals lack of preservation of primary textures in these rocks. Only a couple of samples show ophitic texture, and the fine-grained groundmass has either recrystallized or is completely altered to sericite, epidote, and carbo-

TABLE 2 NORMATIVE AND CHEMICAL ANALYSES OF THE METAVOLCANIC AND INTRUSIVE ROCKS IN HONEYWELL AND McNAUGHTON TOWNSHIPS.

Sample Number	75-2 204	[3]63- 120	[3]63- 119	[4]75-2 734	[3]63- 121	[3]63- 118	[3]63- 117	[4]75-2 185
Rock Name	Basalt	Dacite	Andesite	Dacite	Rhyodacite	Andesite	Basalt	Basalt
Stratigraphic Position	Cycle 1	Cycle 1	Cycle 1	Cycle 1	Cycle 1	Cycle 2	Cycle 2	Cycle 2
SiO_2	46.1	69.7	58.3	60.9	67.4	57.2	47.8	51.3
Al_2O_3	13.7	15.7	13.3	19.4	14.7	16.6	16.7	16.6
Fe_2O_3 [1]	21.0	2.37	5.19	4.86	1.89	6.99	8.44	9.97
MgO	4.84	1.59	5.77	2.24	1.48	3.49	8.20	6.31
CaO	8.93	1.50	4.28	1.91	1.80	4.86	10.9	7.27
Na_2O	2.01	5.32	3.04	5.23	5.45	2.70	1.48	3.75
K_2O	0.76	1.06	0.97	1.80	1.38	2.27	0.02	1.36
TiO_2	1.82	0.44	0.60	0.51	0.42	0.76	0.74	1.21
P_2O_5	0.07	0.08	0.14	0.12	0.46	0.00	0.00	0.43
MnO	0.22	0.07	0.12	0.06	0.46	0.11	0.15	0.18
L.O.I. [2]	0.55	2.38	6.59	3.27	3.11	4.16	4.20	1.11
Total	100.0	100.0	98.5	100.3	98.7	99.7	99.4	99.4
				CIPW Norms				
Q	0.00	26.07	15.84	14.59	23.17	13.33	1.25	0.00
Or	4.79	6.36	6.24	10.87	8.47	14.19	0.13	8.19
Ab	19.23	48.44	29.69	47.93	50.79	25.62	13.99	34.29
An	27.84	7.02	21.52	8.87	6.15	25.49	40.92	24.91
C	0.00	3.62	0.00	6.31	2.35	1.00	0.00	0.00
Mt	3.70	0.28	0.00	2.15	0.23	2.08	1.61	2.89
Il	2.70	0.62	0.91	0.73	0.61	1.12	1.09	1.72
Ap	0.17	0.17	0.32	0.26	1.00	0.00	0.00	0.92
En	8.55	4.45	16.07	6.31	4.24	10.19	19.37	11.72
Fs	12.89	2.98	8.94	2.00	3.00	6.98	8.72	4.59
Di	6.03	0.00	0.30	0.00	0.00	0.00	8.92	5.16
Fo	2.00	0.00	0.00	0.00	0.00	0.00	0.00	2.59
Fa	3.02	0.00	0.00	0.00	0.00	0.00	0.00	1.01
He	9.09	0.00	0.17	0.00	0.00	0.00	4.02	2.02

[1] Fe_2O_3 as total Iron
[2] Loss on Ignition
[3] Analyses from Goodwin (1967)
[4] Analyses by Mineral Research Branch, Division of Mines.

Table 2 continued

Sample Number	[4]75-2 169	[4]75-2 557	[4]75-2 554	[4]75-2 52	[3]63- 116	[3]63- 115	[3]63- 56	[3]63- 57
Rock Name	Basalt	Basalt	Dacite	Dacite	Dacite	Andesite	Basalt	Basalt
Stratigraphic Position	Cycle 2	Cycle 2	Cycle 2	Cycle 2	Cycle 2	Cycle 2	Cycle 3	Cycle 3
SiO_2	43.2	43.4	67.4	67.3	70.6	59.3	47.6	48.5
Al_2O_3	23.8	18.5	12.5	15.5	11.4	12.4	20.0	17.5
Fe_2O_3 [1]	7.05	12.7	8.29	7.67	6.67	12.98	5.65	7.30
MgO	6.25	9.54	1.20	0.76	0.93	3.17	7.10	6.60
CaO	15.1	9.90	1.62	2.18	2.03	4.77	10.6	12.0
Na_2O	1.56	1.50	4.40	4.84	3.61	2.19	1.58	1.50
K_2O	0.13	0.14	0.87	0.61	0.84	0.45	0.82	0.51
TiO_2	0.38	0.79	0.67	0.53	0.59	1.55	0.41	0.46
P_2O_5	0.01	0.01	0.15	0.12	0.00	0.00	0.00	0.00
MnO	0.12	0.18	0.10	0.14	0.10	0.24	0.12	0.16
L.O.I. [2]	3.11	4.59	2.03	1.07	2.52	4.48	4.47	3.35
Total	100.6	101.3	99.2	100.8	99.9	99.5	98.9	98.5
CIPW Norms								
Q	0.00	0.00	29.60	26.66	36.06	20.57	0.00	1.35
Or	0.79	0.86	5.43	3.69	5.25	2.93	5.06	3.18
Ab	7.23	14.06	41.71	44.43	34.27	21.61	14.90	14.20
An	58.84	45.25	7.45	10.26	10.65	24.93	47.35	41.66
C	0.00	0.00	2.00	3.58	0.99	0.00	0.00	0.00
Mt	2.01	2.50	2.40	2.17	1.70	3.51	0.71	1.10
Il	0.54	1.15	0.99	0.76	0.87	2.37	0.60	0.68
Ap	0.02	0.02	0.33	0.26	0.00	0.00	0.00	0.00
En	0.00	8.47	3.50	2.15	2.71	9.44	16.67	13.78
Fs	0.00	3.89	6.59	6.06	7.50	13.78	6.60	7.38
Di	10.70	3.27	0.00	0.00	0.00	0.35	4.53	10.86
Fo	9.22	13.04	0.00	0.00	0.00	0.00	1.24	0.00
Fa	2.97	5.99	0.00	0.00	0.00	0.00	0.49	0.00
He	3.44	1.50	0.00	0.00	0.00	0.52	1.80	5.82

[1] Fe_2O_3 as total Iron
[2] Loss on Ignition
[3] Analyses from Goodwin (1967)
[4] Analyses by Mineral Research Branch, Division of Mines.

Table 2 continued on next page

Table 2 continued

Sample Number	[3]63-58	[4]75-2 515	[4]75-2 59	[4]75-2 512	[3]63-55	[3]63-59	[4]75-2 507	[4]75-2 97
Rock Name	Basalt	Basalt	Basalt	Andesite	Dacite	Dacite	Dacite	Dacite
Stratigraphic Position	Cycle 3	Cycle 3	Cycle 3	Cycle 3	Cycle 3	Cycle 3	Cycle 3	Cycle 3
SiO_2	48.0	46.4	46.3	63.4	68.1	66.6	66.2	67.4
Al_2O_3	16.4	17.8	15.2	12.2	11.4	11.8	14.1	13.7
Fe_2O_3[1]	7.53	11.6	10.2	9.21	6.63	7.97	8.81	8.07
MgO	7.10	7.37	13.5	1.26	0.74	1.01	0.39	0.93
CaO	10.9	10.4	9.66	4.71	2.95	2.00	2.64	1.28
Na_2O	1.72	2.49	1.28	3.57	2.64	4.16	4.73	4.93
K_2O	0.63	0.50	0.36	0.44	1.62	0.43	0.99	0.35
TiO_2	0.44	0.82	0.45	0.81	0.54	0.82	0.44	0.43
P_2O_5	0.00	0.01	0.00	0.21	0.00	0.00	0.03	0.03
MnO	0.14	0.18	0.17	0.20	0.12	0.18	0.18	0.11
L.O.I.[2]	4.90	3.07	2.59	4.27	4.09	2.75	0.39	1.59
Total	98.5	100.7	99.6	100.3	99.3	98.4	98.9	98.7
				CIPW Norms				
Q	0.46	0.00	0.00	26.97	36.14	30.46	23.58	28.86
Or	3.98	3.06	2.17	2.81	10.42	2.73	6.09	2.17
Ab	16.51	23.10	11.73	34.58	25.77	40.09	44.17	46.48
An	37.61	37.12	35.39	17.23	15.73	10.65	13.42	6.46
C	0.00	0.00	0.00	0.00	0.00	1.00	0.59	3.39
Mt	1.32	2.51	2.08	2.61	2.26	2.24	2.11	2.12
Il	0.66	1.18	0.64	1.22	0.82	1.23	0.64	0.63
Ap	0.00	0.02	0.00	0.47	0.00	0.00	0.07	0.07
En	15.54	2.82	16.49	2.91	2.20	2.99	1.12	2.70
Fs	7.71	1.45	4.33	6.01	6.52	8.61	8.21	7.13
Di	10.84	8.53	8.58	1.70	0.04	0.00	0.00	0.00
Fo	0.00	10.46	12.94	0.00	0.00	0.00	0.00	0.00
Fa	0.00	5.38	3.40	0.00	0.00	0.00	0.00	0.00
He	5.38	4.38	2.25	3.51	0.11	0.00	0.00	0.00

[1] Fe_2O_3 as total Iron
[2] Loss on Ignition
[3] Analyses from Goodwin (1967)
[4] Analyses by Mineral Research Branch, Division of Mines.

Table 2 continued

Sample Number	[3]63-74	[3]63-73	[4]75-2 469	[3]63-72	[4]75-2 565	[4]75-2 555	[4]75-2 501	[3]63-122
Rock Name	Basalt	Basalt	Basalt	Basalt	Gabbro	Gabbro	Gabbro	Gabbro
Stratigraphic Position	Cycle 4	Cycle 4	Cycle 4	Cycle 4	Intrusive	Intrusive	Intrusive	Intrusive
SiO_2	47.0	46.9	43.6	46.7	42.4	48.9	46.0	53.4
Al_2O_3	15.0	17.2	17.0	17.1	17.2	13.8	16.8	15.2
Fe_2O_3 [1]	10.10	7.96	11.6	9.51	10.8	19.0	13.7	7.75
MgO	7.03	7.10	7.96	6.15	8.93	4.79	6.52	5.80
CaO	11.6	12.6	14.1	10.7	10.4	6.61	12.2	6.73
Na_2O	1.78	1.62	1.25	2.17	1.67	2.07	2.16	3.06
K_2O	0.02	0.23	0.43	0.13	0.30	0.38	0.29	2.15
TiO_2	0.81	0.51	0.55	0.76	0.54	1.77	0.97	0.64
P_2O_5	0.00	0.00	0.01	0.00	0.00	0.16	0.03	0.00
MnO	0.18	0.16	0.19	0.19	0.16	0.24	0.20	0.14
L.O.I. [2]	4.12	3.83	3.87	4.46	9.42	2.95	1.99	3.97
Total	98.5	98.8	100.5	98.7	101.8	100.6	100.8	99.4
				CIPW Norms				
Q	0.29	0.00	0.00	0.00	0.00	6.06	0.00	2.92
Or	0.13	1.44	2.67	0.82	1.93	2.43	1.77	13.32
Ab	17.11	15.36	8.77	20.83	16.28	20.10	20.06	28.77
An	35.21	41.18	41.46	39.06	41.88	29.46	36.51	22.40
C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mt	2.83	2.22	2.25	2.53	2.32	3.70	2.67	2.34
Il	1.21	0.75	0.80	1.13	0.82	2.67	1.40	0.93
Ap	0.00	0.00	0.02	0.00	0.00	0.36	0.07	0.00
En	14.17	12.60	0.00	12.68	3.49	13.46	1.41	13.30
Fs	8.48	5.37	0.00	7.50	1.45	17.88	1.01	6.00
Di	13.22	13.94	16.79	8.97	8.00	1.67	12.07	6.94
Fo	0.00	0.85	11.0	0.74	14.47	0.00	8.38	0.00
Fa	0.00	0.36	5.71	0.44	6.04	0.00	6.00	0.00
He	7.91	5.94	8.72	5.31	3.34	2.22	8.65	3.12
Ne	—	—	1.81	—	—	—	—	—

[1] Fe_2O_3 as total Iron
[2] Loss on Ignition
[3] Analyses from Goodwin (1967)
[4] Analyses by Mineral Research Branch, Division of Mines.

nate. The plagioclase has also been altered to sericite and epidote, which makes the determination of the primary anorthite content impossible in most cases. The remaining plagioclase is subhedral, untwinned, metamorphic albite. Quartz grains are minor. Chlorite and hornblende are the most common mafic minerals in the mafic flows, with the percentage of hornblende increasing as the Okanse Lake Pluton is approached.

Intermediate Metavolcanics

The intermediate metavolcanics occur in four distinct linear units, and as minor beds and pods within the mafic metavolcanics and metasediments. The classification of pyroclastic rocks used in this report follows that of R.W. Fisher (1966, p.292). The first linear unit is part of the upper part of Volcanic Cycle One. This unit can be traced from just south of Wagner Lake 8000 m north to Wilkins Lake. The average thickness of this unit is 900 m, except for the part that is south of the fault which passes through Wagner Lake. There, the unit is 300 m thick at its widest point, and pinches out completely 2100 m south of the fault. The lithologies identified within this unit consist of interbedded intermediate tuff, lapilli-tuff, and flows. The second linear unit is also a component of the upper part of Volcanic Cycle One. This unit extends from the eastern end of Okanse Lake, 7000 m north to Grace Lake, and has an average thickness of 1700 m. Interbedded intermediate tuff and lapilli-tuff form the dominant lithologies within this unit. A small pyroclastic breccia horizon and two outcrops of intermediate flow are also found within the unit. The third linear unit lies in the upper part of Volcanic Cycle Two. This unit trends from north of Okanse Lake, through Honeywell Lake, to just south of the northern boundary of Honeywell Township, a distance of 6600 m. The unit is 900 m thick south of Honeywell Lake and 450 m thick at its northernmost point. The dominant lithology in this unit is intermediate spherulitic flows with a minor amount of interbedded massive flows and tuff. A wedge of interbedded tuff, lapilli-tuff, and spherulitic flows can be found south of Honeywell Lake stratigraphically overlying these spherulitic flows. The fourth linear unit of intermediate metavolcanics forms the upper part of Volcanic Cycle Three. This unit can be traced over a strike length of 11 200 m from the Honeywell-Agnew Township boundary past Sundown and Washagomis Lakes to the northern boundary of Honeywell Township. It is 2700 m thick at Sundown Lake, and narrows to a thickness of 900 m at the extreme northern end of Honeywell Township. Fine-grained intermediate tuff is the dominant lithology. Intermediate spherulitic flows occur at the base of the unit, and minor lapilli-tuff is found throughout it.

Each linear unit is flanked by mafic metavolcanics. Although actual contacts were not observed at outcrops, the units appear to be conformable. The appearance of the rocks within each intermediate unit varies with their chemical compositions. Andesite has a buff-weathered surface with a medium dark green fresh surface. Dacite, on the other hand, has a cream-coloured weathered surface and a greenish grey fresh surface. The less common rhyodacite has a white weathered surface, and a grey to black fresh surface, depending on the grain size. Dacite is the most common composition for the intermediate rocks in the area (Table 2).

The intermediate metavolcanics are, in order of decreasing abundance: (i) tuff, (ii) flows, (iii) lapilli-tuff, (iv) pyroclastic breccia, and (v) tuff-breccia. In many cases, the intermediate tuffs are difficult to distinguish from the massive intermediate flows.

The intermediate tuffs in the map-area have the following characteristics;

(1) They may or may not be bedded. Where seen on the outcrop, beds range in thickness from 3 to 15 cm. Bedding is rarely recognized from the examination of outcrops, but is commonly recognized in thin section, where beds less than 1 cm in thickness are present. Metasediments, on the other hand, are commonly bedded as can be seen on the outcrop, and

(2) Feldspar crystals and lithic fragments are visible on the weathered surface. The feldspars may be euhedral to subhedral crystals, or angular, crystal fragments ranging in size from microscopic to 2 mm; whereas the andesitic to dacitic lithic fragments are subrounded, and are usually somewhat stretched parallel to foliation.

In the fine-grained tuffs, crystal and lithic fragments can be seen with a hand lens by examining a wet, fresh surface. The outlines of the fragments are poorly defined, and generally gradational with the matrix. Therefore, care is required in ascertaining whether lithic fragments are present or not. Muscovite and chlorite are the common mafic minerals in the intermediate tuffs, whereas biotite is more common in the metasediments, as well as sand sized, subrounded feldspar fragments. The system used in the field and laboratory to classify the intermediate pyroclastic rocks is similar to that used by Fisher (1966).

The intermediate flows in the map-area have the following characteristics:

(1) They are usually massive to slightly foliated,

(2) A wetted fresh surface is very fine grained, dark, and massive in texture with no lithic fragments or crystal fragments visible,

(3) However, some flows are porphyritic with phenocrysts of euhedral, lath-shaped feldspars, and

(4) Some of the flows are spherulitic.

Intermediate tuff is prominent in three of the intermediate units, and minor in the unit that strikes north through Honeywell Lake. The tuff, found in the first linear unit extends 6000 m from Wagner Lake to Wilkins Lake; and in the pod of intermediate metavolcanics just south of Wilkins Lake, is a medium- to fine-grained, well-sorted crystal tuff with euhedral, whole, and broken feldspar fragments. Lithic fragments were rarely found within the tuff. Within this unit, tuffs were found interbedded with intermediate lapilli-tuff and intermediate flows. Since bedding within the tuff horizons was observed only rarely, it was assumed that the beds are reasonably thick.

The second intermediate unit, which extends 9000 m from the eastern shore of Okanse Lake to the southern shore of Grace Lake, is composed predominantly of fine-grained tuff. The tuff is well bedded in a few places, and in one outcrop on Okanse Lake, has two consecutive graded beds which exhibit opposing tops. The graded beds, with opposing tops in close proximity to each other, may indicate that, for a period of time, this part of the volcanic pile was above the wave base. In the northern part of this unit, near Grace Lake, the intermediate tuffs grade laterally and vertically into felsic tuffs. The felsic tuff is interbedded with felsic lapilli-tuff, tuff-breccia, and pyroclastic breccia.

A wedge of tuff, 1800 m long, part of Intermediate Metavolcanic Unit Three, occurs south of Honeywell Lake. These tuffs have been metamorphosed to the hornblende-hornfels facies by the Okanse Lake Pluton. These rocks are fine grained, and well foliated to roughly banded. In thin section, these rocks are equigranular, and have approximately equal percentages of euhedral hornblende and unaltered feldspar. Minor amounts of quartz and biotite are associated with hornblende, magnetite, and epidote grains. There may be remnant lithic fragments, but these are hard to discern because of the degree of metamorphism. Lapilli-tuff and some spherulitic flows occur interbedded with the tuff.

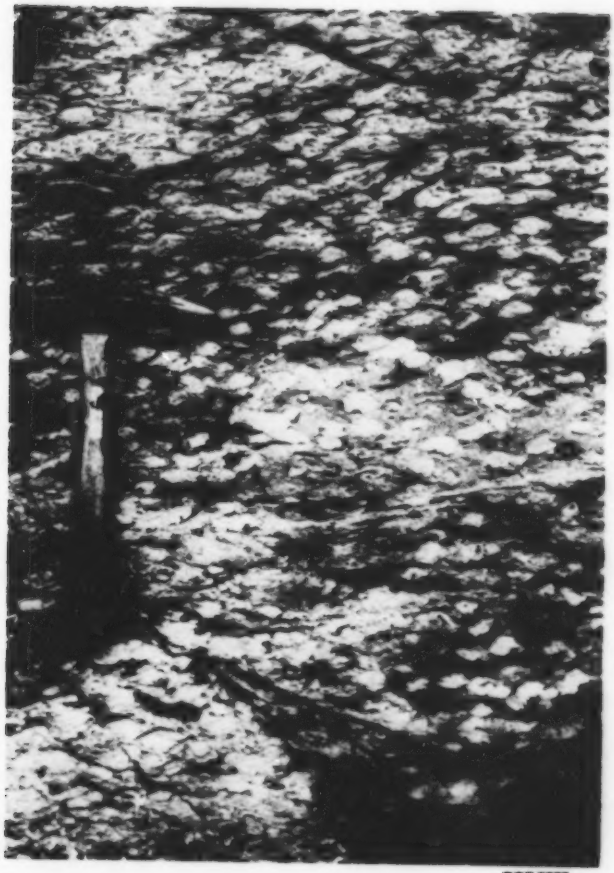
The Four Intermediate Metavolcanic Units extends 10 000 m from the Honeywell-Agnew Township boundary west of Okanse Lake in the south to the northern boundary of Honeywell Township, and is composed predominantly of very fine grained tuff. The tuff outcrops generally have a hackly weathered surface and a glassy appearing fresh surface with faint thin bedding that can be discerned in some outcrops and thin sections.

The mineral assemblage of the tuff consists of the following: untwinned feldspar (80 to 85 percent, estimated mode); amphibole, chlorite, epidote, calcite, quartz, muscovite, and opaque minerals (15 to 20 percent estimated as a group). Minor lapilli-size lithic fragments were also observed in some of the thin sections. The epidote and muscovite are products of the saussuritization of the feldspars. The fine-grained matrix in much of the tuff has been altered to epidote, muscovite (sericite), and calcite. The fine-grained tuff is a crystal tuff composed of 10 to 15 percent of equigranular, subangular, altered feldspar crystals evenly distributed in an aphanitic groundmass consisting of feldspar, sericite, epidote, chlorite, and calcite. The tuff was hypocrystalline (a volcanic rock consisting partly of crystals and partly of glass) when it was originally formed. The glassy matrix devitrified, forming spherulites 0.03 mm in diameter composed of feldspar, sericite, and epidote, and an intraspherulite matrix of chlorite, calcite, and epidote. The tuff contains many fractures that have been filled with quartz-carbonate which contain minor amounts of minor chlorite, hornblende, and epidote.

Flows are found in Intermediate Metavolcanic Units One, Three, and Four and are basically absent in Intermediate Metavolcanic Unit Two. The primary textures and structures in the flows of the map-area consist of, in order of decreasing abundance: (i) spherulites; (ii) massive featureless flows; (iii) porphyritic flows, with feldspar and amphibole phenocrysts and amygdules; and (iv) flow-top breccia and flow layering.

Intermediate Metavolcanic Unit Two which extends from the eastern end of Okanse Lake to Grace Lake, is composed entirely of pyroclastic material, except for two small outcrops of flow material, one of which is 400 m east of the southern part of Bamford Lake, and the other, too small to show on the map, is located 450 m north of the eastern end of Okanse Lake, just west of the felsic tuff band (see Map 2404, back pocket).

The spherulitic flows occur in the two uppermost intermediate metavolcanic units. The spherulitic structures occur throughout the flow part of the Honeywell Lake Belt (Intermediate Volcanic Unit Three)with interbedded intermediate tuff and mafic flows. The spherules are rounded to elliptical, with a diameter of 5 to 6 cm in the southern part of the Honeywell Lake Belt, and are about 1 cm or less in diameter in the northern part of the Honeywell Lake Belt. The spheru-



OGS 9679

Photo 1–Spherulitic intermediate flow. Seen on the southern shore of the lake 2000 m north of Sundown Lake.

lites occur both as single spherules and as coalesced spherules. The spherules are whitish grey on the weathered surface, are very fine grained with a black to dark grey-green fresh surface, and are very hard. No primary radiating textures were seen in outcrop. The coalesced part of a spherulitic flow closely resembles chert. The spherules concentrate along flow lines (Kesler and Weiblen 1968, p.2026), and can be used to determine the strike of a flow unit. Intermediate spherulitic flows can be found north of Sundown Lake bounded by a conglomerate horizon on the west and mafic metavolcanic flows on the east. Photo 1 shows individual and coalesced spherules north of Sundown Lake. The flows are similar in appearance to the spherulitic flows previously described, but have a higher proportion

of interbedded featureless flows and tuffs. The well formed spherulites are circular to elliptical masses approximately 1 by 75 mm and consist of cryptocrystalline aggregates of feldspar and epidote surrounded by a rim of chlorite 0.25 to 0.5 mm thick. Less well defined spherulites occur in flows and some tuffs, and have a crude radiating structure composed of laths of plagioclase feldspar within a fine-grained groundmass. The groundmass consists of feldspar, granophyric feldspar, epidote rods within the feldspars, and 15 to 20 percent chlorite.

The granophyric, spherulitic intermediate flows are found in the lower part of Intermediate Metavolcanic Unit Four, which occurs between Sundown Lake and Washagomis Lake, and are close to the contact with the underlying mafic unit. Granophyric altered feldspars can be found both within poorly developed, or badly altered spherulites, and within the groundmass surrounding the spherulites. These rocks are well fractured, and the fractures are filled with hornblende, chlorite, and untwinned feldspar. The untwinned, unaltered feldspar has also been broken to a minor degree. The textural patterns exhibited by the granophyric feldspars include plumose, parallel, boxwork, radiating, and anastomosing intergrowths of quartz and feldspar (Baker 1970). The cores of the granophyric grains are lath-shaped feldspar which has been altered to sericite. Sericite alteration is pervasive throughout the feldspar grains, but the alteration is not complete in all grains, and may be compositionally controlled. The more highly sericitized crystals are less susceptible to granophyric alteration.

A microprobe study by Kesler and Weiblen (1968) on spherulites in a Cretaceous andesite showed partitioning of certain elements between the interior of the spherulite and the groundmass surrounding the spherulite. Lofgren (1971, p.5,643) and Kesler and Weiblen (1968, p.203) hypothesize a constant temperature environment for the formation of spherules. This would only be possible during the earliest phase of cooling at about 900° to 100°C. The spherulites would form in two days as a result of the concentration of impure elements (potassium) into the area between the fibres in the spherules, and in a peripheral zone around the spherulites (Kesler and Weiblen 1968, p.2,034). The granophyric textures were probably formed after the spherulites, possibly by deuteric alteration or vapour-phase transport within the flow (Baker 1970, p.3,342-3,343).

The next most common type of intermediate flow is the massive megascopically featureless flow which is found interbedded with tuff, lapilli-tuff, and other rocks throughout the intermediate metavolcanic units. The featureless flows are massive to foliated, fine-grained rocks with a composition ranging from andesite to dacite. Porphyritic intermediate flows are rare within the map-area. Feldspar phenocrysts composing about 10 to 15 percent of the rock can be seen in two outcrops 2500 m south-southeast of Washagomis Lake.

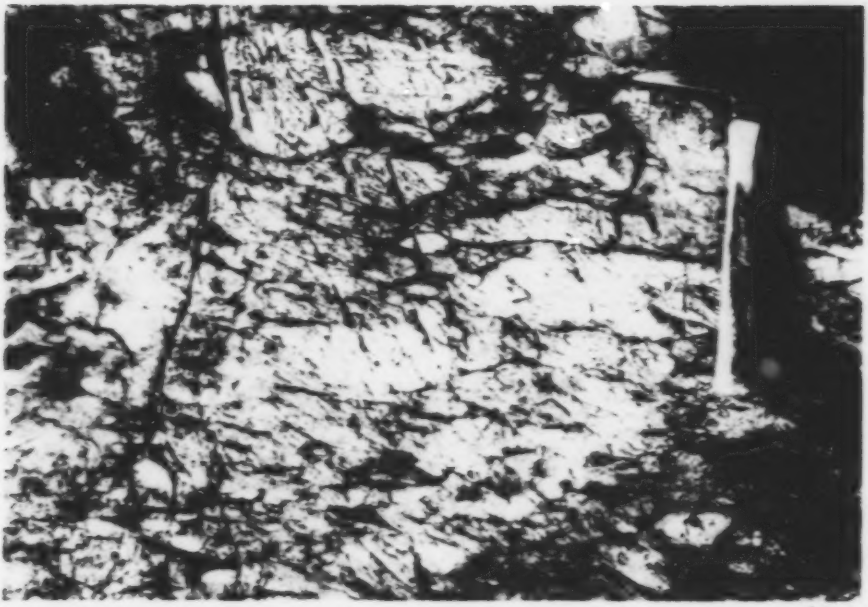
Intermediate amygdaloidal flows can be seen north of these two outcrops of porphyritic intermediate flows, along the contact with the mafic flows of Volcanic Cycle Four. The amygdules consist primarily of quartz, feldspar, and calcite. No pillows were found in the intermediate flows within the map-area. Flow-top breccia [too small to show on map] was found in a few outcrops in the intermediate unit that lies east of Washagomis Lake. The angular fragments, similar in appearance to the massive flows, vary in size from blocks 1 m by 1 m, to lapilli-size, and grade into massive flows. One outcrop shows rafts of chilled flows incorporated in the massive flow as well as lenses of lapilli-size angular fragments and possible flow banding.

The intermediate flows are composed of untwinned feldspars (both sericitized and unsericitized), chlorite, hornblende, biotite, muscovite, sericite, epidote, quartz, calcite, opaque minerals, leucoxene, and stilpnomelane. The flows consisted originally of holocrystalline and hypocrystalline rocks. The glass within the hypocrystalline rocks has been devitrified and metamorphosed to a groundmass consisting of microcrystalline to cryptocrystalline quartzofeldspathic material, epidote, chlorite, and calcite. The holocrystalline flows are porphyritic and equigranular. Stilpnomelane and leucoxene are rare, and are only found in two of the thin sections. Epidote is common within the area, and occurs primarily as microscopic rods within altered feldspar and the groundmass. Sericitic alteration is common throughout the feldspar and groundmass. Calcite occurs as alteration patches and amygdule filling. Opaque minerals consist of pyrite, magnetite, and ilmenite.

Lapilli-tuff is found interbedded with all the flows and tuffs in the intermediate metavolcanic units within the map-area. Fragments found in the lapilli-tuff are predominantly intermediate to felsic lithic clasts with minor crystal fragments. The lithic fragments are all subrounded to subangular, and generally consist of ellipsoidal fine-grained intermediate massive amygdaloidal flows and tuffs, whereas the crystals are subangular, euhedral feldspar or quartz. The matrix of the lapilli-tuff consists of tuff size crystals (>2mm) and lithic fragments. In most cases, outcrops containing lapilli-tuff also have tuff associated with them, and no distinct boundary can be discerned between the two rock types. The size of the lapilli fragments in any one outcrop, within the map-area, is fairly constant. Bedding and grading is rarely observed within the outcrops containing lapilli-tuff. The thick units, lack of obvious grading and bedding, and sorting of lapilli size fragments, may indicate that the majority of the lapilli-tuff was emplaced as a result of subaqueous, pyroclastic flows (Fiske 1963; Fiske and Matsuda 1964).

The pyroclastic breccia is extensive in one area only which is on the northeast shore of Okanse Lake where it strikes northwest for less than 300 m. The best exposures are on the shore and islands around the little bay on the northern shore at the eastern end of Okanse Lake. The fragments are composed of intermediate to felsic tuff, and have a buff white-weathered surface. The fragments are 7 to 46 cm long, 4 to 7 cm wide, and are subrounded. Photo 2 shows the pyroclastic breccia on a little island at the northern end of the aforementioned bay. The matrix is grey on the weathered surface, is more foliated than the fragments, and appears to be composed of mafic to intermediate tuff. The unit is 200 m wide, and is 1000 m minimum long, is faulted to the north, and is submerged beneath Okanse Lake to the south.

Tuff-breccia can be found at two locations within the map-area. On the eastern shore of Okanse Lake, tuff-breccia contains subrounded to subangular roughly elongated fragments which vary in size from 1 cm to 17 cm. The clasts are made up of predominantly very fine grained, hard black fragments, and fine-grained, white, tuffaceous dacitic fragments. Graded bedding indicates that these rocks face westward. This coarse-grained unit alternates between a tuff-breccia and a pyroclastic breccia, and can be traced southward to the Honeywell-Agnew township boundary, a distance of 1600 m. Tuff-breccia may also be seen north of the Honeywell Township boundary, 1400 m (outside the map-area) east of Swain Lake. The outcrops are highly schistose, and the clasts are



OGS 9680

Photo 2–Intermediate pyroclastic breccia. Found on a small island in the mouth of the little bay on the northern shore at the eastern end of Okanse Lake.

stretched. Cream coloured intermediate tuff and dark green mafic clasts are predominant in a matrix of greenish intermediate crystal tuff. A rough bedding is present in the rock. A 70 to 80 cm thick bed occurs, rich in clasts at the base, and grades upward into clasts and tuff matrix. The bed is succeeded upwards predominantly by tuff matrix. In the immediate vicinity, the clasts vary in size, and degree of roundness. Photo 3 shows the best exposed part of this unit of tuff-breccia.

All outcrops of intermediate metavolcanics within the map-area are cut by fractures varying in size from microfractures, visible in thin section only, to veins that are as much as 3 to 4 cm wide. The material filling these fractures varies from quartz-feldspar-carbonate material seen in thin section, and small fractures in diamond-drill core, to epidote in the veins. Pyrite is found in all the intermediate metavolcanics in amounts averaging less than one percent. A large scale fining upwards cycle is present through the various intermediate metavolcanic units. The intermediate pyroclastic rocks in the eastern part of the map-area appear, on the average, to be coarser grained than those found in the western part of the map-area.

OGS 9681

Photo 3–Intermediate tuff-breccia. Note elongated bombs and tuffaceous matrix. Found just north of Honeywell Township, 1400 m east of Swain Lake.

Felsic Metavolcanics

Felsic metavolcanics are found within three of the intermediate units which make up two of the volcanic cycles. The second volcanic cycle did not contain any felsic metavolcanics. The felsic metavolcanics, primarily pyroclastic in origin, occur interbedded with, and grade laterally into, intermediate metavolcanic pyroclastic rocks. The majority of the felsic metavolcanics encountered in the

map-area are found in Volcanic Cycle One, particularly in the northern part of the second intermediate unit. The most common lithologic type is tuff; lapilli-tuff, tuff-breccia, lapillistone, and flows occur in decreasing amounts. The felsic metavolcanics have white-weathered surfaces, pale green to light grey fresh surfaces, and are very hard and brittle with a conchoidal fracture.

The felsic tuff is found as thick beds, greater than 15 cm thick, in units that are 100 m to 1000 m thick, traceable for as much as 4000 m along strike, and as thin occurrences which are as much as 6 m thick in single outcrops of intermediate metavolcanics. The appearance of the tuff varies from that of a fine-grained bedded crystal tuff to a very fine grained non-bedded crystal tuff, and also to an aphanitic non-bedded tuff. The most common type of tuff is crystal tuff that has a grain size varying from fine grained to very fine grained (0.5 mm to 0.02 mm), and is shown on Map 2404 as Unit 3b. The tuffs are well sorted, but are also found occurring with lenses and beds of lapilli-tuff. The aphanitic tuff found on the western shore of Grace Lake in Honeywell Township is very hard, and breaks with a well-defined conchoidal fracture. The outcrops have a white, hackly, weathered surface, and a black fresh surface. Because of their brittleness, the outcrops tend to be brecciated with a cementing material consisting of epidote veinlets. Crystal tuff consists of 30 to 40 percent feldspar crystal in a fine-grained quartzofeldspathic groundmass. Alteration is sericitic with muscovite pseudomorphic after feldspar. Epidote and carbonate is also found associated with the feldspar crystal fragments forming stringers and clots, and with the quartzofeldspathic groundmass. Fragments of quartz were observed in the felsic unit of Volcanic Cycle Three just south of the northern border of Honeywell Township.

Felsic lapilli-tuff is found associated with the felsic tuff, and is concentrated in the region around Grace Lake. Lapilli-tuff consists of lapilli-size fragments of felsic tuffaceous and flow material in a groundmass of crystal tuff. The lithic fragments are all roughly 4 to 5 cm by 1 to 2 cm and are stretched, and/or flattened parallel to bedding and foliation. The lapilli-tuff grades laterally and vertically into felsic tuff, and bedding is poor to indistinct. Lapilli-tuff and tuff are cut by a quartz-feldspar porphyry sill which outcrops as far as 1700 m north of Sundown Lake.

A number of individual outcrops of felsic tuff-breccia occur in the vicinity of Grace Lake. These rocks consist of angular, equidimensional, blocks of felsic tuff 5 to 50 cm in size, forming 30 to 40 percent of the rock set in a matrix of felsic to intermediate tuff and lapilli-tuff. The blocks have a random orientation and no bedding was observed. One occurrence of lapillistone is found along the eastern contact of the conglomerate with the intermediate tuff, 600 m north of Sundown Lake. The fragments are less than 64 mm in diameter, and are subangular to subrounded. The fragments are all felsic tuff with very little matrix. The matrix, where seen, is a fine-grained intermediate to felsic tuff.

Felsic flows were found in two locations in the map-area, one on the west shore of Sundown Lake, and the other on the eastern shore of the large pond, north of Wagner Lake on the Okanse River. The flows are very fine grained, hard, and have a hackly weathered surface. Quartz eyes are occasionally seen in the flow.

The composition of the felsic unit varies in composition between intermediate and felsic. Several units thought to be felsic on the basis of fracture, colour of the weathered surface, and other criteria were found on the basis of chemical

analysis, and/or petrographic examination, to be dacitic or rhyodacitic in composition. Therefore, in the map-area, great care is required during the field examination of outcrops that appear on first sight to be felsic metavolcanics, to identify them correctly.

Geochemistry

Twenty-eight partial chemical analyses and norms of samples taken from the metavolcanic sequence are listed in Table 2. The partial chemical analyses reported in Table 2 consist of the ten major oxide values, plus loss on ignition, and were done by the Geoscience Laboratories, Ontario Geological Survey. Fifteen of the analyses in Table 2 were taken from Goodwin (1967), and were included to facilitate comparison between them and the partial analyses from this project. Four partial analyses from gabbroic units are also included in Table 2. Of the 28 metavolcanic samples analysed, 15 are basalts, 3 are andesites, 9 are dacites, and 1 is a rhyodacite using the criteria of Irvine and Baragar (1971).

An AFM ternary diagram (Figure 2), using the tholeiitic and calc-alkaline fields of Irvine and Baragar (1971), was plotted for all the rocks analysed including the gabbroic rocks. The volcanic cycles appear to have distinct chemical characteristics as indicated by the groupings shown in Figure 2. Only five analyses are available of Volcanic Cycle One rocks, and the trend cannot be established with any certainty, but a normal calc-alkaline differentiation trend seems to be present. The mafic part of Volcanic Cycle One has a tholeiitic composition, and the intermediate and felsic part of the cycle is calc-alkaline in composition.

Volcanic Cycle Two has the most varied composition. The mafic metavolcanics fall into an iron-rich and an average iron tholeiitic basalt field (Figure 2). The average iron basalts have about the same iron content as Volcanic Cycle Three basalts, but a lower alkali content. The intermediate metavolcanics are grouped into a calc-alkaline andesite field and a tholeiitic dacite field. The tholeiitic dacite field is on the left side of the diagram (Figure 2), above the dividing line. The tholeiitic dacite of Volcanic Cycle Two appears to have a lower iron content than the tholeiitic dacite of Volcanic Cycle Three.

The basalt of Volcanic Cycle Three is tholeiitic, and has an average iron content. The iron content of Volcanic Cycle Four basalt is similar to that of Volcanic Cycle Three. The major difference between the two basaltic cycles is the higher magnesium content of the Volcanic Cycle Three basalt. The intermediate metavolcanics of Volcanic Cycle Three consist of tholeiitic dacite and andesite.

Excluding the iron-rich basalt of Volcanic Cycles One and Two, the iron content of the volcanic cycles increases in the intermediate and mafic rocks of the younger units. The alkali content appears to remain constant in Volcanic Cycles Three and Four of the average iron basalt, but both cycles have higher alkali contents compared to Volcanic Cycle Two. In the average basalt and dacite of Volcanic Cycles Two and Three, the magnesia content has remained relatively constant, but there was a decrease in magnesia content in the Volcanic Cycle Four basalt compared to the Volcanic Cycle Two and Volcanic Cycle Three basalts.

The gabbroic to dioritic rocks that were analysed by the Geoscience Labora-

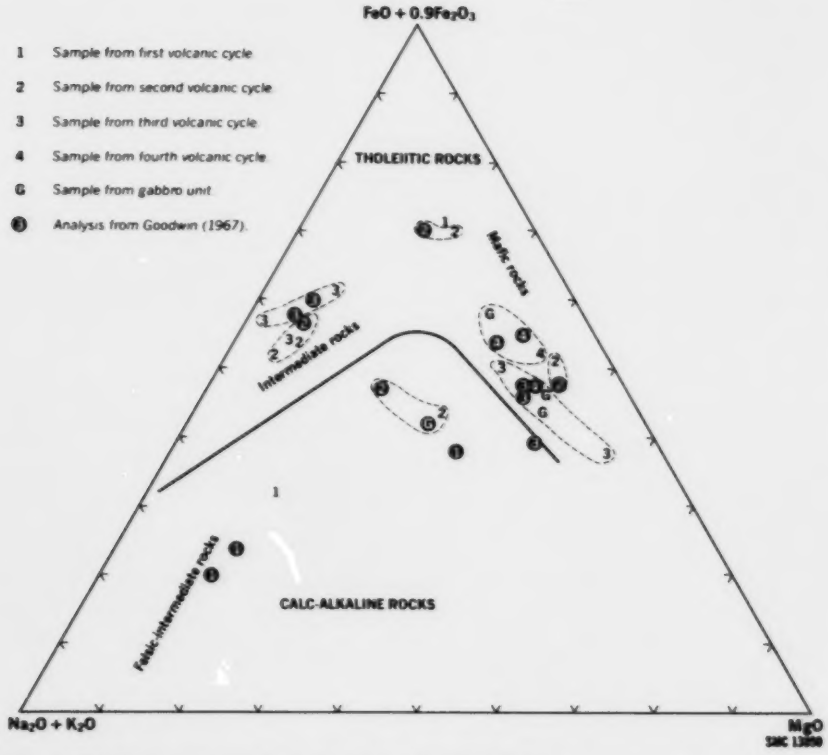


Figure 2–AFM diagram of samples; after Irvine and Baragar (1971).

tories, Ontario Geological Survey, are plotted on the AFM ternary diagram shown in Figure 2. These rocks plot within the field of the volcanic cycle they are associated with in the map-area. The intrusive rock plotted with the calc-alkaline andesite of Volcanic Cycle Two is from the island at the western end of the west arm of Grace Lake. The intrusive rocks that are plotted with the tholeiitic basalt of Volcanic Cycle Three, are from the unit that is at the base of Volcanic Cycle Three at the northern end of Honeywell Township. The gabbro plotted close to the tholeiitic basalt of Volcanic Cycle Four is from the gabbro that is situated on the western side of the Okanse Lake Pluton. These differing chemical affinities indicate that each gabbro unit is directly associated with each volcanic cycle, and was probably emplaced roughly synchronously with the volcanic rocks. Thus, the gabbroic bodies appear to decrease in age from east to west.

METASEDIMENTS

Metasediments underlie approximately 31 percent of the map-area. The metasediments occur in three major units and several minor units intercalated with the metavolcanics. The oldest rocks in the area are the metasediments of the Slate Lake Series (Bateman 1939). These rocks were found underlying the mafic unit in McNaughton Township, and were intruded by the Cook Lake Pluton. The next major metasedimentary unit is considered by the author to be part of the Uchi Series (Goodwin 1967), and strikes north from the McNaughton-Costello townships border, through Wagner Lake to the region east of Wilkins Lake. The third metasedimentary unit occurs along the western side of Sundown Lake. Minor lenses of metasediments were found along the northern contact of the Okanse Lake Pluton. The metasediments in the map-area are classified according to the system of McBride (1963). In order of decreasing abundance the metasediments found in the map area are: wacke, conglomerate, arenite, and mudstone.

Clastic Metasediments

Wacke

A wacke, according to McBrides classification (McBride 1963), is a sedimentary rock composed of feldspar, quartz, and lithic fragments with 15 to 75 percent fine-grained (clay sized) matrix. Because metamorphism has recrystallized the metasediments, the percentage of mafic minerals was taken to indicate the percentage of fine-grained matrix present in the sediment. The wacke found in the map-area was found to be composed of recrystallized quartz, feldspar, biotite, and rock fragments with minor muscovite, chlorite, hornblende, garnet, and cordierite. These rocks are fine grained, poorly sorted, and commonly bedded. Graded bedding is common and truncated. Crossbedding as well as flame structures are rarely found. Beds range in thickness from 2 to 3 cm to greater than 1 m. Wacke is usually associated with varying amounts of arenite, conglomerate and mudstone. The wacke has a buff-grey weathered surface and a darker grey fresh surface than these other rocks.

The Slate Lake Series is predominantly feldspathic lithwacke with thin lenses of conglomerate and lesser amounts of mudstone. A minor amount of intermediate tuff occurs just east of McNaughton Lake which is north of Cavano Lake, and north of McNaughton Creek. The rocks are well foliated to schistose, the fabric is defined by the arrangement of the biotite and muscovite grains. As the Cook Lake Pluton is approached, muscovite appears in the metasediments. Minor amounts of garnet and cordierite were observed in the rocks east of the Cook Lake Pluton. A 300 m wide zone around the Cook Lake Pluton has been highly altered by the intrusion. The greywacke is gneissose, and has 2 to 5 mm thick contorted, alternating leucocratic and biotite rich-bands. Small lenses 8 by 20 cm composed of thick leucocratic, granitic material occur within this zone.

These lenses are parallel to the schistosity, and are discontinuous. They are medium grained, equigranular, and show no cross-cutting relationships or chilled margins. This rock type is termed a stromatic (layered) migmatite by Mehnert (1968, p.18), and is formed by partial melting and exudation of melt into the wacke. Wackes in the Slate Lake Series have no recognizable relict sedimentary textures. The framework grains of quartz and feldspar have been enlarged by recrystallization, and bedding is obscure. The matrix is primarily composed of biotite, with some chlorite starting to appear around the Cook Lake Pluton. The percentage of quartz varies between 10 to 60 percent, and the proportion of lithic fragments ranges from 5 to 15 percent.

Lithic arkosic wacke is predominant south of Wagner Lake, and is shown on Map 2404, as unit 4a (back pocket). It occurs with interbedded argillite, arenite, and paraconglomerate as well as minor intermediate tuff. Quartz pseudomorphs after andalusite are prominent in one wacke bed 450 m south-southwest of Wagner Lake. Cordierite was found south of Wagner Lake. The lithic arkosic wacke is finer grained than the feldspathic lithwacke of the Slate Lake Series, and contains a higher percentage of lithic fragments. Graded bedding, crossbedding, lamination, and flame structures are easily seen.

A recrystallized wacke occurs in the minor metasedimentary units flanking the Okanse Lake Pluton. Here, the metasediments have been metamorphosed to the hornblende-hornfels facies, and are equigranular and sugary in texture. No primary structures or textures were observed. Quartz is predominant, and has embayed outlines. Feldspar is altered to sericite and epidote, and the magnetite is rimmed by muscovite. Lithic fragments compose about 20 percent of the rocks. Minor intermediate tuff and mafic flows are interbedded with the metasediments.

The presence of interbedded wacke, arenite, argillite, and conglomerate suggests a turbidity current origin for the metasediments (Walker 1976).

Conglomerate

Conglomerate is found in varying amounts in all the metasedimentary units. The clasts are fairly well rounded and generally greater than 64 mm in diameter (in the cobble range). Matrix-supported and clast-supported conglomerates occur with a matrix of wacke, and less commonly argillite matrix. Intermediate and felsic tuff form the most common clasts. Mafic flow material, metasediments, and felsic intrusive rocks also occur in minor amounts as clasts in the conglomerate.

The minor lenses of conglomerate in the Slate Lake Series have a greywacke matrix and a disrupted framework. They occur in the vicinity of the eastern end of McNaughton Lake.

The conglomerate found south of Wagner Lake is matrix supported and has a wacke to mudstone matrix. Between Wagner and Wilkins Lakes, and east of Wilkins Lake interbedded conglomerate, arenite, wacke, and argillite occur. The conglomerate is commonly a pebble conglomerate with well-rounded clasts averaging 2 to 4 cm in diameter. Matrix-supported conglomerate is most common, and coarse-grained feldspathic arenite is the matrix material. Some clast-sup-

OGS 9882

Photo 4–Orthoconglomerate with an arenite matrix. Photo taken on a little island in Grace Lake just north of the McNaughton Township line.

ported conglomerates occur, and they have larger clasts which are approximately 8 cm in diameter. The coarser grained conglomerate occurs north of Wilkins Lake, around the shore of Grace Lake. The rock is primarily a clast-supported cobble conglomerate with an arkosic matrix. Clast sizes range from 2 cm to 30 cm. Arkose commonly occurs in beds up to 47 cm thick between the conglomerate beds. These beds are massive; no primary structures were observed in them. Photo 4 was taken on a little island in Grace Lake just north of McNaughton Township, and shows orthoconglomerate with an arenite matrix.

The conglomerate around Sundown Lake has large, well-rounded clasts. The clasts define an intact framework, and are all composed of, in order of decreasing abundance, intermediate tuff, intermediate flows, and mafic flows with an average size of 6 to 7 cm. Bedding was not observed in this conglomerate. The unit is 5000 m long and 450 m thick at the midpoint of the unit and pinches out 1500 m north of Sundown Lake. Garnet was observed in the greywacke matrix at the southern end of Sundown Lake.

Argillite

Metasediments with greater than 75 percent fine matrix are classified herein as argillite.

Argillite is most commonly found in the metasedimentary unit that underlies Wagner, Wilkins, and Grace Lakes, and is interbedded with wackes, conglomerate, and arenite. Argillite is highly schistose along the shore of Grace Lake north of the old Sol d'Or Mine, and occurs in contorted 5 to 10 mm thick beds, having a grey to black weathered surface, and a dark grey to black fresh surface. In some outcrops, the thin beds occur as units of several beds as much as 15 cm thick interbedded with wacke. Graphitic argillite occurs as interflow sedimentary rocks in the metavolcanics. These occurrences are minor, and can be found 300 m north of the northeast end of Okanse Lake and on the south shore of the western arm of Grace Lake.

Siltstone is not common in the metasedimentary units, but occurs as intraformational material in the metavolcanic sequences. Siltstone was observed by the author to form single outcrops in two locations: one 180 m west of Grace Lake, north of the old cabin, and the other just north of the point where the Okanse River flows into Okanse Lake. Siltstone is equigranular, very fine grained, and is composed primarily of quartz and graphitic matrix.

Arenite

An arenite is a sedimentary rock composed of feldspar, quartz, and lithic fragments, and has less than 15 percent fine-grained matrix. Arenite is common around Wilkins Lake where it occurs interbedded with conglomerate, and wacke. Arenite is yellowish grey on the weathered surface and light grey on the fresh surface. Beds tend to be 2 to 3 cm thick, and contain less than 15 percent fine-grained mafic minerals as matrix. The framework is composed of feldspar and minor quartz with a matrix of chlorite, carbonate, and muscovite.

Arkose

Lithic arkose occurs as individual beds within the conglomerate, and as the matrix material in the conglomerate of the region. Lithic arkose is composed pre-

dominantly of angular feldspar fragments about 1 to 3 mm in diameter set in a matrix of finer grained material composed of feldspar, carbonate, muscovite, and quartz, as well as approximately 10 percent lithic fragments. Walker's (1976) synthesis of depositional models places the deposition environment for arkosic material and conglomerates close to the mouth of a feeder channel that supplies sediment to the depositional basin.

Metamorphism

The map-area has undergone regional dynamothermal metamorphism up to the andalusite-cordierite-muscovite subfacies of the cordierite-amphibolite facies of the Abukuma-type facies series (Winkler 1967). Contact metamorphism to the hornblende-hornfels facies is observed around the Okanse Lake and Cooke Lake Plutons.

Chemical Metasediments

Iron Formation

Iron formation by definition (Gross 1965, p.83) contains more than 15 percent iron. Iron formation in the map-area consists of two types: oxide facies and sulphide facies.

The oxide-facies material occurs in the upper to middle part of the mafic flows of Volcanic Cycle Two. The iron formation is exposed discontinuously east of Honeywell Lake, west of Bamford Lake, as well as southwest and west of Grace Lake in Honeywell Township. The unit can be traced from the northern edge of the Okanse Lake Pluton 6400 m north to the Honeywell Township boundary. Where best exposed, the sedimentary band containing the iron formation has a thickness of about 48 m. Another short band of oxide-facies iron formation occurs on the northeast side of Bamford Lake, in the lower parts of the mafic flows of Volcanic Cycle Two. The oxide facies iron formation consists of units, 3 to 4 m thick consisting of alternating jasper and magnetite in a very fine grained foliated argillite lying conformably on the coarse-grained mafic flows.

The argillite, associated with the iron formation, has graded bedding in magnetite- and quartz-rich beds about 1 cm thick. The magnetite-poor beds are very fine grained, and nearly opaque with the majority of the material appearing to be chlorite.

The jasper beds are very fine grained, red, and have an average thickness of 5 mm and range in thickness from laminae less than 1 mm to beds 10 to 15 mm thick.

The magnetite-rich beds are fine grained, grey, and have an average thickness of 5 mm, and range in thickness from 0.8 mm to 8 to 10 mm. The bedding is well preserved, convoluted, and irregular, that is, a magnetite bed does not al-

ways follow a jasper bed. In some places, two or three jasper beds occur together. The percentage of magnetite varies within the iron formation, but an average content is estimated to be 10 to 30 percent. A grab sample of the iron formation, analysed by the Geoscience Laboratories, Ontario Geological Survey, has 26 percent iron and 0.01 to 0.10 percent copper. On an island in the lake due west of Grace Lake, the iron formation is intruded along bedding planes by metagabbro.

Some trenching of the iron formation has been done northwest of this lake, but no assessment reports were filed for the work which exposed a maximum width of 3 m.

According to Goodwin (1973, p.922), oxide-facies iron formation could be a product of relatively shallow water volcanic exhalative activity, but there are no shallow water clastic sedimentary rocks associated with the iron formation.

Sulphide-facies iron formation was observed in an arc 480 m long, concave to the west, 900 m southeast of the southern shore of Wagner Lake. The sulphide-facies iron formation occurs in the upper part of the mafic metavolcanic flows of Volcanic Cycle One. Banded pyrite occurs as 2 to 3 cm thick beds separated by 5 to 8 cm thick beds of fine-grained, black argillaceous metasediment. The sulphide-facies iron formation units are 2 to 3 m wide, and occur in lenses up to 15 m long.

Pyrite is also found as stringers and crystals in the surrounding mafic flows, which increase in density as massive lenses of sulphide-facies iron formation are approached. The massive lenses of granular pyrite are 3 to 4 m wide and vary in length. The host rock in the immediate area of the massive lenses of pyrite is very rusty, making identification difficult. The soil above the mineralized zones is also extremely rusty and thickly forested.

Sulphide-facies iron formation is a product of deep water volcanic exhalative activity (Goodwin 1973, p.922). Pyrite was probably deposited in a depression in the volcanic flows as indicated by the curved nature of the iron formation, and may be of limited areal extent. The occurrence was sampled in three locations by the field party, and was found to contain trace constituents as follows; 0.01 to 0.10 percent chromium, 0.01 to 0.10 percent cobalt, 0.01 to 0.10 percent copper, 0.01 to 0.10 percent lead, 0.01 to 0.10 percent nickel, 0.1 to 1.0 percent titanium, and 0.01 to 0.10 percent vanadium.

The range of each element listed above was derived from semi-quantitative spectrographic determinations made by the Geoscience Laboratories, Ontario Geological Survey.

METAMORPHOSED MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS

Metagabbro and metadiorite sills and local dikes form approximately 7 percent of the rocks within the map-area, and range in thickness from a few metres to 1,200 m. Ultramafic phases are locally present in some sills, especially in the metagabbro complex that lies along the Honeywell-McNaughton township boundary. Some of the sills and dikes are too small to be shown as separate units on the map (Map 2404, back pocket), but are labelled as single outcrops in other units. The metagabbro intrusions are, for the most part, concordant with the metavolcanic metasedimentary stratigraphy, but local discordances are seen along their contacts with the host rocks.

Metagabbro is commonly fine to medium grained (1 to 2 mm), and has isogranular to ophitic textures that vary from sill to sill. Metagabbro and metadiorite were metamorphosed under primarily greenschist facies conditions. The colour of fresh surfaces is dark green, and of weathered surfaces is buff-brown to dark green.

The Philchub Lake Metagabbro Complex (P.C. Thurston, Geologist, Precambrian Geology Section, Ontario Geological Survey, personal communication, 1974) occurs east and south of Okanse Lake, and extends from the Honeywell-Costello township boundary, 6700 m to the north. It is 600 m wide at the northern end of the complex, and is 1500 m wide in the south end, and may include the gabbro that is found at the exit of the Okanse River into Okanse Lake.

In the map-area, this complex consists of two sills separated by a 100 m wide septum of mafic metavolcanic flows. Associated with the complex, are large, outcrop-size inclusions of the metavolcanic-metasedimentary sequence. Pods of more mafic material are found within the complex and may be the result of differentiation. Narrow horizons of knobby weathered gabbro, with ovoids of amphibole and feldspar ranging in size from 5 to 10 mm, are found within the Philchub Lake Gabbro, and is the result of differential weathering of ophitic textured phases of the complex.

Grain size within the complex ranges from fine grained (1 mm) to coarse-grained, with plagioclase glomerophenocrysts up to (1 to 2 cm) in size. Epidote veins and stringers are common. Some mineral layering is seen accompanied by zones that are depleted in mafic minerals. Around these depleted zones, a concentration of long laths of amphibole is seen in many places.

Contamination by host-rock xenoliths can be seen along the northern side of the little bay in Okanse Lake that the Okanse River empties into. Clots and stringers of leucocratic material are seen to be set in a matrix of chlorite and gabbroic material. Blue quartz eyes in amounts up to 15 percent are also seen in this material. This area may be a zone of gabbroic intrusion breccia, and the fragments are partly assimilated and recrystallized intermediate tuff.

The only sill to have a partly dioritic composition lies at the northern end of the first lake west of Grace Lake. The outcrops showing a dioritic composition have a coarse-grained, leucocratic to mesocratic appearance; amphibole is the predominant mafic mineral. Some fine-grained mafic xenoliths, less than 50 cm long are scattered throughout the outcrops. The dioritic material grades into gabbroic material over a few metres, and appears to be the result of differentiation.

Metagabbro, with one exception, is massive and equigranular. The long narrow metagabbro sill situated west of Okanse Lake has a coarse-grained porphyritic phase at its northern end. Amphibole and feldspar phenocrysts are present. The feldspar phenocrysts vary in size from 2 mm to 20 mm, and are glomerophorphyritic in places. The amphibole phenocrysts having a constant size, are around 10 mm long, 3 mm wide, and tend to arrange themselves in radiating clusters. The southern part of this sill is a medium-grained gabbro similar in appearance to the rest of the metagabbro in the map area. Other large sills in the map-area also have small zones that are porphyritic with feldspar and amphibole phenocrysts.

Numerous smaller sills and dikes can be seen throughout the map-area. Generally, they are fine to medium grained, massive and different in appearance

from the surrounding metavolcanics. A metagabbro with 5 to 10 percent quartz phenocrysts occurs on the shore of the first lake north of Sundown Lake. Some of the metagabbro contains enough magnetite to cause a magnetic attraction in localized areas.

In the greenschist facies rocks, primary pyroxene has been completely replaced by uralite(Deer, Howie, and Zussman 1966,p.174). Alteration of the gabbros has been such that pyroxene pseudomorphs were rarely recognized in thin section. The amphibole grains are mantled around their edges by aggregates of magnetite, chlorite, and some biotite. Feldspar crystals have been highly altered to sericitic and microscopic epidote rods. Minor amounts of orange-brown stilpnomelane were seen in some of the metagabbros.

Chemical analyses (Table 2, Sample Number 75-2-501, 75-2-555, 75-2-556, 63-122) of four metagabbros indicate that these rocks have basaltic compositions with a calc-alkaline affinity. The metagabbros may be the product of late stage volcanism, because most of the basalts have a tholeiitic affinity.

Metagabbro sills texturally resemble the fine- to medium-grained interiors of thick mafic flows, but can be distinguished from the flows by the following characteristics: (1) they are coarser grained, on the average (1 mm to 2 mm) than the flows (1 mm); (2) epidotization does not occur in the gabbros; and (3) foliation is poorly developed, and many sills are massive.

Except for isolated outcrops within the other metagabbro bodies, the Philchub Lake Complex is the only body with ultramafic phases. These ultramafic bodies, predominantly serpentinized peridotite, occur as thin,concordant, discrete sills, 300 to 450 m long and 30 to 45 m wide, within the gabbro, commonly at the base of the sill. Serpentinized peridotite is a soft, highly altered rock which has a greenish black to black fresh surface and a weathered surface which is lighter coloured. The weathered rind is commonly 1 to 1.5 cm thick, and contains much carbonate.

Metapyroxenite also occurs at the base of the Philchub Lake Complex, such as on the eastern side, 4800 m north of the southern boundary of the map-area along the Honeywell-McNaughton township boundary. This zone is 1000 m long and 60 m wide. The metapyroxenite has a soft, coarse-grained dark weathered surface and a black fresh surface. Some small grains of primary pyroxene are seen in thin section and are partly altered to anthophyllite. Antigorite occurs as small crystals and veinlets. Chlorite, talc, and epidote are predominant in the groundmass. Minor altered feldspar and sphene as well as stilpnomelane also occur. A pod of metapyroxenite is also found at the top of the Volcanic Cycle Three mafic volcanic rocks just north of the Okanse Lake Pluton. The rock has a coarse grained, black, weathered and fresh surface. Very little or no feldspar is seen in hand sample. These rocks may be a recrystallized part of the mafic flows.

METAMORPHOSED FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

Three felsic to intermediate sills occur as mappable units within the map-area. Other exposures occur as single outcrops and are not traceable as units. A 1300 m long, 100 m wide sill of felsic quartz-feldspar porphyry occurs on the western side of the exposure of conglomerate, just north of Sundown Lake. In

hand specimen, the feldspar crystals are white, stumpy, euhedral, and compose 75 to 80 percent of the rock. Quartz is seen as grey, vitreous, anhedral grains between the feldspar crystals, and composes 15 to 20 percent of the sample. Minor amounts of chlorite form the rest of the material found in the sill.

An intermediate feldspar porphyry sill, 700 m by 60 m is exposed, parallel to stratigraphy, 850 m southwest of the southern end of the eastern arm of Grace Lake. This sill resembles intermediate tuff, and care should be taken when examining the unit because feldspar phenocrysts closely resemble crystals and broken crystals in a fine-grained tuffaceous matrix. The distinction between the rock being a porphyry or a tuff was made by examining thin sections of it. Potassium feldspar phenocrysts are subhedral, 3 mm in diameter, and are altered to sericite. The fine-grained, epidotized quartzofeldspathic groundmass has been brecciated and re-cemented with chlorite. Feldspar phenocrysts compose 15 to 20 percent of the rock; the groundmass composes 70 to 80 percent, and chlorite approximately 10 percent of the rock.

A mafic feldspar porphyry unit occurring 300 m west of the southern end of Wagner Lake can be traced for 360 m parallel to the stratigraphy. The sill is narrow, has an apparent width of 15 m and has the appearance of intermediate lapilli-tuff because the "lapilli size" subrounded, feldspar phenocryts resemble volcanic fragments in a fine-grained crystalline matrix. Thin section examination reveals that some of the phenocrysts have microcline twinning and contain rods of epidote. Amphibole is the primary mafic mineral, and remnants can be seen surrounded by fibrous amphibole. Amphibole has reaction rims of biotite, and some crystals have been totally altered to biotite. Minor magnetite, with rims of muscovite, also is revealed in the thin section. Calcite occurs throughout the rock as clots and stringers.

FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

Three intrusive bodies occur within the map-area. Part of a major batholith intruding the Slate Lake metasediments outcrops in the extreme southeastern corner of McNaughton Township. An elliptical pluton, 6700 m by 4100 m, is found in McNaughton Township between Argosy Lake and Cook Lake. This pluton is herein named the Cook Lake Pluton. The northern part of the Okanse Lake Pluton is centred on Okanse Lake in Honeywell Township. The pluton is 7300 m wide. The plutons are all medium to coarse grained, massive, with white to pinkish weathered surfaces, and vary from being roughly equigranular to porphyritic.

The Okanse Lake Pluton has four phases that can be identified on a mineralogical basis. Because of poor exposure, no age relationships between these phases could be observed. The phases were distinguished on the basis of the percentage of quartz in the rock, and the ratio of amphibole to biotite. The first phase, an amphibole-oligoclase-chlorite syenodiorite (Ayres 1972; Ayres *et al.* 1971) contains less than 10 percent quartz, and contains more amphibole than biotite. It is found along the western edge of the Okanse Lake Pluton, and intrudes intermediate tuff. It is also found in contact with the metavolcanics south of Honeywell Lake. An amphibole-rich phase containing 10 to 20 percent quartz occurs west of Okanse Lake and on the large round island in eastern

OGS 9883

Photo 5–Intrusive breccia. Amphibolite quartz monzonite to granodiorite intruding intermediate tuff on an island in the southeastern corner of Okanse Lake.

Okanse Lake. This phase is an amphibole-oligoclase trondhjemite to quartz diorite.

Amphibole-oligoclase quartz monzonite to granodiorite occurs in two locations:

1) In a zone between the amphibole-oligoclase diorite to syenodiorite and amphibole-oligoclase trondhjemite to quartz diorite west of Okanse Lake; and

2) Along the south shore of Okanse Lake.

A biotite-rich quartz monzonite to granodiorite phase is located along the eastern shore of Okanse Lake (Photo 5). The quartz monzonite to granodiorite phase contains greater than 20 percent quartz by volume. The percentage of

mafic minerals in all phases varies between 15 and 30 percent by volume. Lensoidal amphibole xenoliths in amounts of less than one percent were common in the pluton, and range in size from a few cm to 180 m. Intrusion breccia can be observed on the island at the east boundary of the pluton in Okanse Lake. Dikes and stringers of granitic material are found in the metavolcanics around the pluton. The percentage and size of the stringers increase in the metavolcanics as the pluton is approached.

The Cook Lake Pluton has five distinct phases which are listed and described as follows.

(1) The most common phase is an amphibole-oligoclase diorite to syenodiorite. This phase contains less than 10 percent quartz, and is found on the western boundary and in the middle of the pluton. A mafic-rich phase of the diorite to syenodiorite occupies a zone between the northwest bay of Cook Lake and the western end of Argosy Lake. This zone is very coarse grained, and contains up to 90 percent amphibole and biotite. The biotite occurs in large books, and forms 10 to 20 percent of the mafic mineral content. The rock is dark green to black on weathered surface, and dark green on the fresh surface. Outcrops of this rock type were also observed northeast of Argosy Lake.

(2) A biotite-rich part of the oligoclase diorite to syenodiorite occurs, as a separate phase, around Cook Lake. Except for the mafic-rich part, the mafic mineral content of these quartz-poor phases is about 20 percent.

(3) Amphibole-oligoclase trondhjemite to quartz diorite occurs along the western side of the pluton from Argosy Lake south to the southern boundary of McNaughton Township. This phase has 10 to 20 percent quartz, and 10 to 15 percent mafic minerals.

(4) A quartz-rich phase of amphibole-oligoclase quartz monzonite to granodiorite occurs within this phase, 1400 m southwest of Argosy Lake.

Amphibole xenoliths occur within this pluton, but to a lesser extent than in the Okanse Lake Pluton. Pegmatite dikes are common to the west of the pluton, and they range up to 10 m across. Dikes and stringers of granitic material are common in the Slate Lake metasediments to the north, south, and east of the pluton.

The only part of a large batholith which lies to the southeast of the map area, occurs in the extreme southeastern part of McNaughton Township, and consists of coarse grained, leucocratic, biotite quartz monzonite to granodiorite.

The emplacement of the Okanse Lake and Cook Lake Plutons disrupted bedding in the metavolcanics and metasediments surrounding the plutons. The composition of both plutons appears to be affected very little by host rock assimilation. The northern part of the Okanse Lake Pluton, south of Honeywell Lake, appears to have a shallow depth because aeromagnetic maps for the region show a magnetic high extending into the granitic terrane.

STRATIGRAPHY

Stratigraphic correlation in the metavolcanic-metasedimentary sequence is straightforward because faulting is not extensive, and units can be traced

throughout the map-area. Five mafic metavolcanic, four intermediate to felsic metavolcanic, and three major metasedimentary formations have been recognized. From the base of the mafic unit in McNaughton Township, the metavolcanic-metasedimentary belt is approximately 12 200 m wide. Correlation between the formations is shown by four columnar sections in Figure 3 and the locations of the sections are shown in Figure 4. Bateman (1939) defined the metasediments that underlie the predominantly metavolcanics as the Slate Lake Series. The Uchi Series, as re-defined by Goodwin (1967), consists of the predominantly volcanic rock assemblage of the Birch-Uchi Lakes area, which overlies to the north and west the Slate Lake metasediments, and is itself intruded by younger, predominantly granitic rocks.

Contacts between formations are poorly exposed, but appear on the basis of structural interpretation to be relatively sharp and conformable. In the southeastern corner of Honeywell Township, however, the usual pattern of mafic metavolcanic units overlain by predominantly intermediate metavolcanic units is not present; instead there is an intimate interlayering of mafic and intermediate units. The metavolcanic formations form three complete to incomplete mafic to intermediate-felsic volcanic cycles. The base of a possible fourth volcanic cycle is also exposed.

Volcanic Cycle One rocks, the lowest cycle, have a total width of 6000 m. When corrected for folding, the thickness of the cycle is 2700 m. The cycle comprises two mafic units, one of which is totally within McNaughton Township. The other lies along the Honeywell-McNaughton township border. Rocks of this cycle have been intruded by gabbro sills, and are flanked by two intermediate units. Volcanic Cycle One is thicker around Grace Lake, because it includes interlayered intermediate and felsic pyroclastic rocks. This cycle has been complicated by folding, which includes a minimum of one syncline and one anticline.

Near Grace Lake, the metavolcanics are predominantly coarse, felsic pyroclastic deposits of the type commonly found in the regions around volcanic vents. The possibility for the existence of a paleovent to the north of Grace Lake should be considered.

Volcanic Cycle Two is about 2500 m thick, and consists of a mafic unit that extends to the eastern arm of Grace Lake and thickens to the north, and an intermediate spherulitic flow unit with some associated intermediate tuff. The mafic unit has included in it a thin band of jasper iron formation which can be traced for most of the length of Honeywell Township. The mafic unit thickens toward the northern part of the area, as the distance from the iron formation to the base and top of the mafic unit increases from south to north. This assumes that the iron formation is a time stratigraphic unit. Since the flows thicken to the north, the vent for this cycle may have been to the north of the map-area. Volcanic eruption of both the mafic and intermediate phases appears to have been relatively quiet because very little pyroclastic material was deposited in this cycle.

Volcanic Cycle Three has a thickness of about 4600 m including the conglomerate unit. The cycle includes the mafic metavolcanic flows located between Sundown Lake and Honeywell Lake, and the intermediate spherulitic flow and tuff unit that lies between Sundown Lake and Washagomis Lake. The pyroclastic rocks, except for some in the northern part of the metavolcanic-metasedimentary unit, all consist of fine-grained tuff. This indicates that the depositional en-

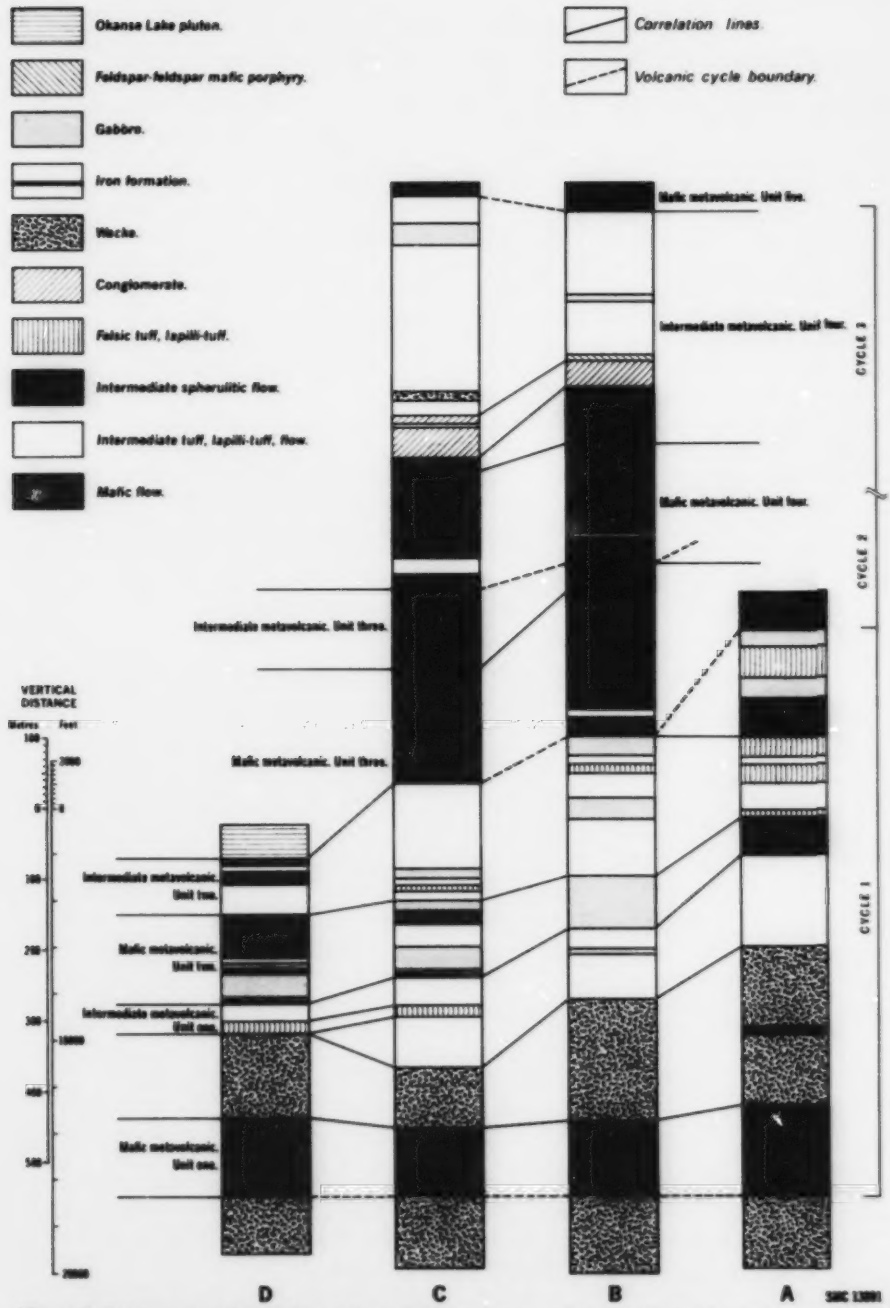


Figure 3–Columnar sections taken at the locations shown on Figure 4. The solid lines are approximate correlation lines between metavolcanic units. Dashed lines outline the proposed volcanic cycles. Volcanic Cycle Four overlies Volcanic Cycle Three.

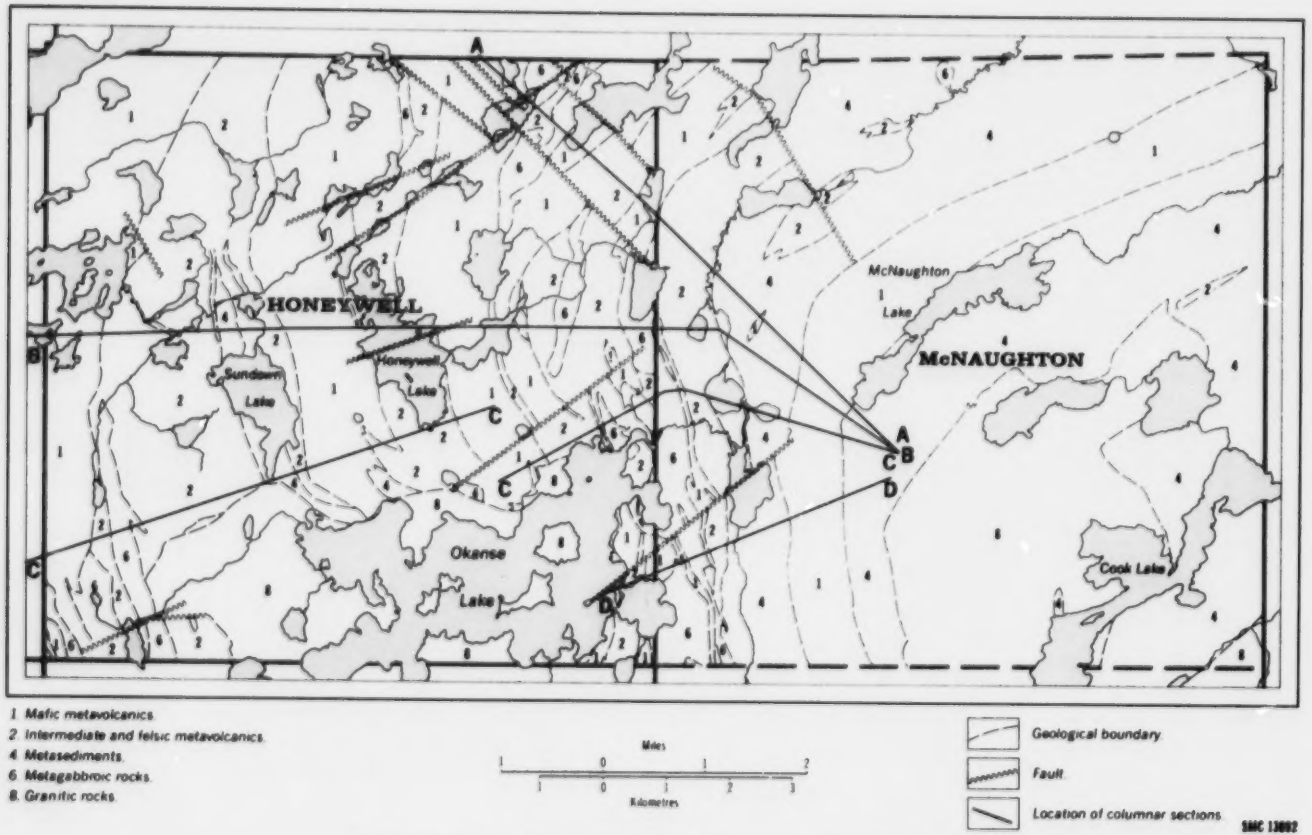


Figure 4–Location map for columnar cross-sections shown in Figure 3.

vironment for these rocks existed some distance from the vent area.

The base of Volcanic Cycle Four is exposed along the western side of Honeywell Township on both sides of the synclinal axis. The base consists of mafic pillow lavas and pillow-breccia. The top of the cycle has either been removed by erosion, or was never deposited within the map-area.

Within the metavolcanic cycles, there are intraformational occurrences of metaconglomerate, metagabbro, and meta argillite. The majority of these occurrences are located just north of the Okanse Lake Pluton. The sedimentary rocks appear to have been deposited as thin, quiet water basin deposits. The metasediments occur in roughly the same location, with respect to possible vent areas, within each of the three volcanic cycles. Thus, the same quiet depositional environment probably existed in the section around Okanse Lake during deposition of all four volcanic cycles. No evidence that sedimentation occurred between the volcanic cycles was found in the map-area. This indicates that the volcanic rocks may have been deposited in rapid succession. The metasedimentary unit between Wagner and Wilkins Lake was probably deposited at the same time or shortly after the deposition of the upper part of Volcanic Cycle One because conglomerate found around Grace Lake contains predominantly felsic pyroclastic and minor mafic flow cobbles with an arenite matrix.

Phanerozoic

CENOZOIC

Quaternary

PLEISTOCENE

During the Pleistocene Epoch, the map-area was glaciated, and the ice from the most recent ice sheet, the Wisconsinan, retreated from the map-area between 9,000 and 9,500 years ago (Prest 1970). The ice sheets and subsequent glacial lakes modified the pre-Pleistocene topography by removing weathered rock, smoothing rock ridges, and filling intervening valleys.

Direction of Ice Movement

Glacial striae are present in a few places on outcrops, and can be best seen on water-washed outcrops along lake shores and stream banks and have an average trend of S55°W. Local divergences in this trend probably reflect irregularities in bedrock surface. Many outcrops are roches moutonnées, with gently sloping northeast sides, and steeply sloping, plucked southwest sides which show that the last movement of the ice was in a southwesterly direction. Glacial gouging

and scouring are also present on the striated outcrops. The west-southwesterly trend of ice movement conforms to trends in nearby areas (Prest *et al.* 1968).

Morainic Deposits

Except for outcrop areas, most of the bedrock is covered by a thin layer of ground moraine of undetermined thickness. Only the upper surface of the moraine is exposed, and it is composed of boulders, cobbles, pebbles, and sand. The general absence of clay, and the abundance of large clasts suggest that the upper surface of the moraine may be a concentrate produced by glacial lake action. Extensive areas of ground moraine occur around Okanse Lake in Honeywell Township, in McNaughton Township, east of Grace Lake, and west of Bertha Lake (northeast of McNaughton Township), and most of the area southeast of McNaughton Lake.

Glaciofluvial Deposits

Glaciofluvial deposits consist of flat areas of sand, and rarely, gravel that appear to be thick. The sand occurs in the northern part of McNaughton Township, and southeast of Cook Lake. The sand plains are flat and poorly vegetated because the drainage is so complete that the vegetation is always in need of water.

RECENT

Recent deposits comprise lacustrine and fluvial clay, silt, and sand, which are presently being deposited in creeks and lakes, and organic mud which is being deposited in swamps and muskeg. Wave action in lakes has locally formed boulder and cobble deposits by washing away the morainic deposits. Recent sand beaches are common on the shores of lakes surrounded by glacial moraine, and are possibly formed from sand washed out of the moraines.

Recent swamp and muskeg is abundant in McNaughton Township, and between outcrop areas in Honeywell Township. These have generally developed in areas where ground moraine has not completely filled in depressions in the bedrock.

STRUCTURAL GEOLOGY

Bedding, Foliation, Schistosity, and Gneissosity

Bedding is present in many of the metasedimentary, metavolcanic, and pyroclastic rocks. The beds are generally less than 15 cm thick, and some are graded, giving excellent top determinations. The bedding, except where it is disrupted by the Okanse Lake and Cook Lake Plutons, strikes north in the southern part of the map-area, and swings to the northeast and east in the northern part. The bedding was deformed in a southeasterly direction around the edge of the Okanse Lake Pluton. Dips are predominantly vertical with minor variation.

Most of the metavolcanics and metasediments except for the very fine grained flows and tuffs, have poor to well-developed metamorphic foliation and schistosity produced by subparallel orientation of amphibole, chlorite, biotite, and muscovite, and by the stretching of fragments in clastic and pyroclastic rocks. Foliation is absent in the metagabbro, and except for one location on the southeast shore of Okanse Lake, is absent in the Okanse Lake and Cook Lake Plutons.

Foliation is generally parallel to the primary structures such as bedding and flow direction. Discordant foliation is found in the metavolcanics in the vicinity of the Okanse Lake Pluton. The foliation tends to be parallel to subparallel to ward the edge of the pluton. This is most pronounced between Sundown and Honeywell Lakes, and south of Honeywell Lake. The mafic flows and metasediments just north of Okanse Lake and southeast of Honeywell Lake do not appear to have been deformed to any great extent by the pluton. Local discordances between foliation and bedding occur around some of the faults where foliation tends to be parallel to the fault trend.

Schistosity is rare in the map-area, and occurs primarily in the Slate Lake metasediments east of the Cook Lake Pluton. Schistosity is discordant to bedding in the metasediments, and tends to be subparallel to the contacts of both the Cook Lake Pluton and the major batholith that is present in the extreme southeastern corner of McNaughton Township. Schistosity in the metasediments parallels the fault that strikes northwest just north of the Sol d'Or Mine on Grace Lake. Schistosity is also found in the metavolcanics on Swain Lake where it parallels the shore. Pryslak (1974) has proposed a major fault through Swain Lake, which would account for the schistosity.

Gneissosity was observed in the Slate Lake metasediments along the eastern contact of the Cook Lake Pluton. The wacke gneiss consists of contorted 2 to 5 mm bands of foliated leucocratic material and foliated biotite-rich material. The gneissosity occurs in outcrops within a zone 300 m thick, that occurs next to the pluton, and has been produced by heating and partial melting of the sedimentary rocks by the Cook Lake Pluton.

Folds

The axis of a major synclinal structure proposed by Goodwin (1967, p,42) strikes northeast through the northwestern corner of Honeywell Township. Opposing pillow tops in the mafic flows enabled the synclinal axis to be located accurately.

Volcanic Cycles Two and Three of the Uchi Lake Series within the map-area are part of a homoclinal sequence on the eastern limb of the synclinorium. Within Honeywell Township, all top determinations, with the exception of one location southeast of Sundown Lake, indicate that the volcanic stratigraphy youngs to the west.

Volcanic Cycle One appears to be structurally more complex. Seven top determinations, using graded beds, in the metasedimentary unit that runs through Wagner Lake to Wilkins Lake, exhibit opposing, east-facing tops. Thurston (geologist, Precambrian Section, Ontario Geological Survey, personal communication, 1975) has found opposing, east-facing tops in this unit to the south in Costello Township. Pillow determinations on the lowest stratigraphic mafic unit in McNaughton Township indicate west-facing tops. A band of felsic tuff along the Okanse River north of Wagner Lake has graded beds indicating west-facing tops. An outcrop of intermediate tuff at the entrance of the Okanse River into Okanse Lake also has a west-facing top. Thurston (geologist, Precambrian Section, Ontario Geological Survey, personal communication, 1975), found opposing east-facing tops south of the eastern end of Okanse Lake in Agnew Township.

Based on the above information, the author suggests that a syncline in the metasediments extends through Wagner Lake to Wilkins Lake. The axial plane of the fold runs approximately through the centre of the metasedimentary unit. More work will need to be done in the area in order to accurately delineate the trace of this axial plane. The existence of an anticline is also proposed, and the author suggests that the axis of the anticline runs through the metagabbro sills which are parallel to the metavolcanic stratigraphy along the Honeywell-McNaughton township boundary, and north through the mafic metavolcanics that lie between the two arms of Grace Lake. The fold is not traceable north of the northwest-trending fault at Grace Lake. More work is needed to prove or disprove this hypothesis.

Faults and Lineaments

A number of faults of limited lateral extent have been recognized in the metavolcanic-metasedimentary sequence, and hamper stratigraphic correlation. Two predominant fault sets were observed, one striking northwest and the other northeast. The faults were not exposed in outcrop, but in most cases a linear topographic feature was the only surface expression of the fault. Except for the northwest-striking fault which trends across the eastern arm of Grace Lake cutting off the the metavolcanics in the north, all faults in the map-area have less than 600 m of horizontal displacement. The majority of the faults are concentrated in the lower part of the volcanic pile in the area, and especially so in the

vicinity of Grace Lake.

Faults paralleling the stratigraphy were neither found in outcrop nor as obvious topographic lineaments on areal photographs. A major north-trending structure called the Uchi Fault by Thurston (geologist, Ontario Geological Survey, personal communication, 1975), may extend into the map-area striking through the western end of Okanse Lake, continuing north between Sundown and Honeywell Lakes, and may be part of the lineament that lies 2900 m east of Swain Lake along the northern border of Honeywell Township. The Okanse River, east of Wilkins Lake, follows a northeast-striking lineament.

Satellite images obtained from the ERTS programme were examined for large-scale features that might extend through the map-area. The existence of a major new lineament is proposed. The proposed lineament would extend east-northeast from the southern end of Trout Lake, 32 km southwest of the map-area, through Narrow Lake in Skinner Township, curve to the northeast, and cross the northern part of Woman Lake in Goodall Township, through the eastern bay of Washagomis Lake, cross Honeywell Township, and extend northeast through the western arm of Grace Lake. The lineament then curves off to the east through South Bay and Exit Bay on Birch Lake, and extends into the granitic terrain after going through Springpole Lake [out of the map-area], 16 km northeast of McNaughton Township. This lineament has a strike length longer than 80 km. The surface expression of this lineament in Honeywell Township is the series of small lakes between Washagomis Lake and Grace Lake. Northeast-striking faults are also indicated in this zone, which is approximately 1200 m wide, by the right-lateral offsets in stratigraphy.

ECONOMIC GEOLOGY

Parts of Honeywell and McNaughton Townships were staked during the gold exploration rush in 1926 and 1927. The Sol d'Or Mine, a result of this activity, produced $7,500 in gold (20 dollars and 76 cents per ounce, 1929) before it ceased operation after 1936 (dollars were presumably Canadian). The average grade of the material mined is calculated by the author to be 1.11 ounce gold per ton. Prospecting activity in the area was quiet until 1969-1970 when all available ground in Honeywell Township was staked after the discovery of the South Bay Mine in Dent Township.

Claims in good standing as of December 31, 1975 include the ground around the old Sol d'Or Mine, and two claims 1000 m west of the north end of Sundown Lake.

During the field season, many quartz veins, over 15 cm wide, and outcrops containing greater than 1 percent sulphide minerals were sampled. The samples were assayed and/or had a qualitative spectrographic analysis done by the Geoscience Laboratories, Ontario Geological Survey. All the metavolcanics examined by the field party in the map-area contained on average less than 1 percent pyrite.

Gold and Silver

Gold occurs in quartz veins and sulphide-rich parts of the metavolcanics and metagabbroic rocks in the map-area. The only quartz veins which on assay yielded gold above trace amounts occur near the old Sol d'Or Mine property (see Figure 5 for the assay results). A grab sample taken by the writer from a pile of crushed quartz vein material, near a pit of highly carbonatized gabbro northwest of Grace Lake, was found to contain 0.27 ounce gold per ton (Geoscience Laboratories, Ontario Geological Survey), and trace amounts of silver. A grab sample taken by the author from an old pit blasted into rusty gabbro 180 m north-northwest of the cabin on the western shore of Grace Lake was found to have 0.01 ounce gold per ton (Geoscience Laboratories, Ontario Geological Survey). A grab sample taken by the writer from a mafic flow, 520 m south-southeast of the southern end of the northernmost bay on the eastern side of Okanse Lake, contained 2.3 percent pyrite, assayed at 0.02 ounce of gold per ton (Geoscience Laboratories, Ontario Geological Survey).

Silver, assaying at 0.34 ounce per ton, was found in a grab sample of pyrite-bearing intermediate tuff taken by the writer 180 m east of the south end of the northern bay on the east side of Okanse Lake (Assay by Geoscience Laboratories, Ontario Geological Survey). Other sulphide occurrences tested by the author contained only traces of silver.

Spectrographic Analyses

Twenty-five grab samples were taken by the field party in the map-area, for a forty-element qualitative spectrographic analysis to be done by the Geoscience Laboratories, Ontario Geological Survey. Sixteen of these samples were taken from metavolcanics containing an average of 3 to 5 percent pyrite. Nine of the samples were from quartz veins greater than 15 cm in width. The quartz veins were assayed for gold and silver, as well as the forty-element spectrographic analysis.

All the quartz veins in the map-area contained pyrite in amounts averaging less than 1 percent. The spectrographic analyses of the quartz samples indicated that all the veins sampled contained traces of chromium, manganese, iron, and titanium. The quartz veins sampled from the old Sol d'Or Mine workings also contained 0.01 to 0.10 percent nickel.

All the sampled and analysed sulphide-bearing metavolcanics contained traces of chromium and manganese, as well as iron and titanium which occurred in slightly greater amounts. Other trace elements found in various samples include cobalt, copper, nickel, lead, vanadium, yttrium, zinc, and zirconium. The abundance of all these trace elements were in the 0.01 to 0.10 percent range. Not all the samples analysed contained all the aforementioned elements. Chalcopyrite was not found on the surface by the field party, but minor amounts have been reported in diamond-drill holes (see Section "Description of Properties"). The field party found a minute trace of galena and sphalerite in a small vein in intermediate tuff 1500 m southwest of Wilkins Lake.

Information on file with the Resident Geologist, Ontario Ministry of Natural Resources, Red Lake pertaining to properties in Honeywell and McNaughton Townships is listed in Table 3.

TABLE 3 INFORMATION ON PROPERTIES IN HONEYWELL AND McNAUGHTON TOWNSHIPS ON FILE WITH THE RESIDENT GEOLOGIST, ONTARIO MINISTRY OF NATURAL RESOURCES, RED LAKE, AS OF DECEMBER 31, 1975.

File Name	Township	Property Reference Number (see Map 2404, back pocket)	Type of Work
Boylen, M.J. and Associates	Honeywell	1	AM, AEM, R
Huston, C.C. and Associates (Firth Claim Gp.)	McNaughton	10	AM, AEM, M, Em, R
Long Lac Mineral Expl. Ltd.	Honeywell	2	Am, AEM, AR, R
Ronda Copper Mines Ltd.	Honeywell and McNaughton	4; 11	G, Gr, IP, P
Selco Mining Corp. Ltd.	Honeywell	6	DDH
St. Joseph Expl. Ltd.	Honeywell	5	M, EM, R, DDH
Vanco Expl. Ltd. (Dome Group)	Honeywell	7	DDH
Vanco Expl. Ltd. (Sundown Gp.)	Honeywell	8	G, GR, AM, AEM, EM, SP, R
Williams, Cyril	Honeywell	9	S, T

Abbreviations used:

DDH — Diamond drill hole
G — Geological map
GR — Geological report
R — Report
AM — Airborne magnetometer survey
AEM — Airborne electromagnetic survey
AR — Airborne radiometric survey
M — Magnetometer survey
EM — Electromagnetic survey
P — Prospectus
IP — Induce polarization survey
SP — Self potential survey
S — Stripping
T — Trenching

DESCRIPTION OF PROPERTIES

The descriptions of properties held on 31st December 1975, are headed with the full name of the company or person who owned the property. Descriptions of properties with a showing marked on Map 2404 (back pocket), but no longer held, are headed by a name derived from the company or party who carried out exploration work. An unclaimed parcel of explored land in which no mineral showings were located is headed by the full name of the company or person who held the land, and by the date in square brackets of the last major work undertaken. The number in parentheses refers to property numbers shown on Map 2404, back pocket.

Parts of Honeywell and McNaughton Townships were staked during the gold exploration rush in 1926 and 1927. The only deposit discovered in the map-area was the Sol d'Or Mine, an account of which is given under Ronda Copper Mines Limited (Sol d'Or Mine; 4 and 11).

All the available ground in Honeywell Township was staked in 1969-1970 after the discovery by Selco Mining Corporation Limited of base-metal mineralization at the South Bay Mine in Dent Township. All the following property descriptions, except for Ronda Copper Mines Limited and St. Joseph Explorations Limited, are based on assessment work filed at the Resident Geologist's Office, Ontario Ministry of Natural Resources, Red Lake. As of December 31, 1975, Ronda Copper Mines Limited (Sol d'Or Mine; 4 and 11) and McIntyre Mines Limited (3) were the only companies holding property in Honeywell and McNaughton Townships.

M.J. Boylen and Associates [1969] (1)[1]

In 1969, M.J. Boylen and Associates held 144 claims located in the southwestern part of Honeywell Township. The claim area is underlain by the Okanse Lake Pluton and the lower part of Volcanic Cycle Three and Volcanic Cycle Four of the metavolcanic sequence. Part of the metaconglomerate that underlies Sundown Lake also underlies the claim group. Airborne magnetometer and electromagnetic surveys were flown over the claims in 1969. No follow up work was done, and the claims were allowed to lapse.

Firth Occurrence (10)

An airborne geophysical survey carried out in the fall of 1968 for C.C. Huston and Associates resulted in the staking of 36 claims in McNaughton Township by N. Firth southeast of Wagner Lake. The area of the claim block is underlain by mafic metavolcanics of Volcanic Cycle One in the east, and by wacke in the west. In 1969, a ground magnetometer and electromagnetic survey was car-

[1]The number in parentheses refers to property numbers shown on Map 2404, back pocket.

ried out without any significant results being reported. The claims were allowed to lapse.

Long Lac Mineral Exploration Limited [1969] (2)

In 1969, Long Lac Mineral Exploration Limited held 259 claims in the eastern half of Honeywell Township extending from Okanse Lake on the south to the township boundary on the north. The claims are underlain by the Okanse Lake Pluton in the south. The metavolcanics underlying the northern part of the claims consists of the intermediate and felsic part of Volcanic Cycle Two, the majority of the Volcanic Cycle Two mafic and intermediate units and the various gabbros that have intruded the sequence. Airborne magnetic, electromagnetic, and radiometric surveys did not give encouraging results, and no follow up work is on file for the claims. The claims were allowed to lapse.

McIntyre Mines Limited (3)

McIntyre Mines Limited staked two claims, KRL443842 and KRL443843 which are 1000 m southeast of Washagomis Lake. The property is underlain by interbedded, very fine grained intermediate tuff and fine-grained intermediate flow rocks. During the 1975 field season, geological, magnetometer, and electromagnetic surveys were carried out along cut lines (personal communication, Ian Atkinson, Geologist, McIntyre Mines, 1975). The claims were in good standing as of December 31, 1975.

Ronda Copper Mines Limited (Sol d'Or Gold Mine) (4) and (11)

The Ronda Copper Mines Limited property, in 1975, consisted of 24 unsurveyed claims, KRL397543 to KRL397566 inclusive owned by R.J.Charron and A. Wasitis. These claims are situated on the old Sol d'Or Mine site in the northeastern corner of Honeywell Township, the northwestern corner of McNaughton Township, and the vicinity of Grace Lake.

The original Sol d'Or claims were staked in 1927 for the T.W.Bathurst Syndicate. They were then taken over by the newly organized Rainbow Lake Gold Mining Company Limited in 1927. A camp was erected and development of the mine site consisted of a small shaft 10.4 m deep (Harding 1936, p.18). The name of the company was changed in 1930 to Rainbow Lake Gold Mines Limited. The ground then came open for staking, and in 1932, was restaked by Earl McDougall, and then leased to T.W. Bathurst. A 3-ton Jack Nutt Mill was installed, and in the winter of 1932-1933, 100 tons of ore were treated and $1,500.00 worth of gold was shipped to the mint in Ottawa (Furse 1933, p.45). In 1934, the property was acquired by the Sol d'Or Gold Mines Limited, and in 1935, a 5-ton Straub Mill with amalgamation plates and concentrating table were installed. Mining operations were almost exclusively confined to the open-cut veins. Up to

July, 1935, about 400 tons of ore were milled to yield $7,500 worth of gold (Harding 1936, p.19).

The following is Furse's (1933, p.42-45) description of the Sol d'Or Mine property, then called Bathurst Mines:

This group of claims is situated in the western part of Grace Lake. The rocks are basalts, acidic tuffs, and a small body of diorite. Seven veins were examined; six lie in the central and northern part of claim KRL10790, and the other in the northeast corner of KRL10788. No. 1 vein strikes N80°E, and dips 67°N. It is exposed continuously for 300 feet [90 m], varies in width from 5 to 18 inches[12.7 to 45.7 cm], and is composed of a moderately coarse-grained, glassy, light-grey quartz cemented by a finer quartz and siderite. In narrow sections considerable orthoclase occurs. A trace of gold was found.

No. 2 veins is about 400 feet [120 m] long and lies 55 feet [16.8 m] north of No.1 and approximately parallels it, dipping 60°N. It cuts a small, dark-grey dioritic dike.

No. 3 vein is about 1,000 feet [300 m] long, strikes N70°E, and dips 45°N. At the west end it consists of a number of stringers about 2 inches [5 cm] wide, which appear to be barren, but contain a small amount of tourmaline. A few chains east the vein is about 2 feet [0.6 m] wide and follows the south or footwall of a dioritic sill. The vein contains inclusions of the diorite, which, in turn, contains inclusions of the rhyolitic wall rock. A pit shows the vein to be about a foot [0.3 m] wide in the diorite, which is about 6 feet [1.8 m] wide. The cribbing obscures a deformation zone in which the east portion of the vein is offset 4 feet [1.2 m] north. Several irregular quartz stringers occur in this zone and unite immediately to form the easterly continuation of the vein. The vein carries some fine pyrite, as does the diorite hanging wall. In thin section, the vein is exposed almost continuously for a distance of 150 feet [45.7 m]. Farther east it becomes a series of small stringers and also a vein breccia.

Vein Nos. 4, 5, and 6 are quite small and have been exposed for a length of only a few feet.

Vein No.7 has been tested by several trenches and 3 pits over a length of 800 feet[240 m]. At the west end this vein is a rusty, carbonated silicified zone in chloritic schist, striking about S25°E and dipping about 80°S. The central part of the zone is a silicified chloritic schist slightly mineralized with fine pyrite and arsenopyrite. Two chains east, siderite stringers in the schist are cut by minute quartz veinlets carrying pyrite. At the east end, a pit 20 feet [6 m] deep shows at the bottom a shear zone 2 feet [0.6 m] wide in a carbonated and silicified yellowish grey schist. Traces of chalcopyrite, pyrite, and arsenopyrite occur, and gold is reported from the pit. A 2½ foot [0.67 m] chip sample taken from the bottom assayed one-tenth of an ounce gold.

The mine site was mapped and sampled by the field party in 1975 and the results of the assays are shown in Figure 5.

The Ronda Copper Mines Limited property is underlain by the metavolcanics of Volcanic Cycle One. The eastern part of the claim group is predominantly underlain by mafic metavolcanics with some conglomerate, and the western part is underlain by felsic tuff which has been intruded by a gabbroic body.

Early in 1974, three lines of an induced polarization survey were completed on the property, these confirmed two anomalous zones trending east-west about 150 m apart (Northern Miner Press 1975). A geological survey was carried out over the property in the summer of 1974, and in early 1975, another induced polarization survey was carried out. During the winter of 1976, diamond drilling was done on the property.

St. Joseph Explorations Limited [1973] (5)

St. Joseph Explorations Limited held three claim groups in the northwestern quadrant of Honeywell Township. Claim Group A , consisting of six claims, two of which, are outside the township, lay 2400 m east of the northwestern cor-

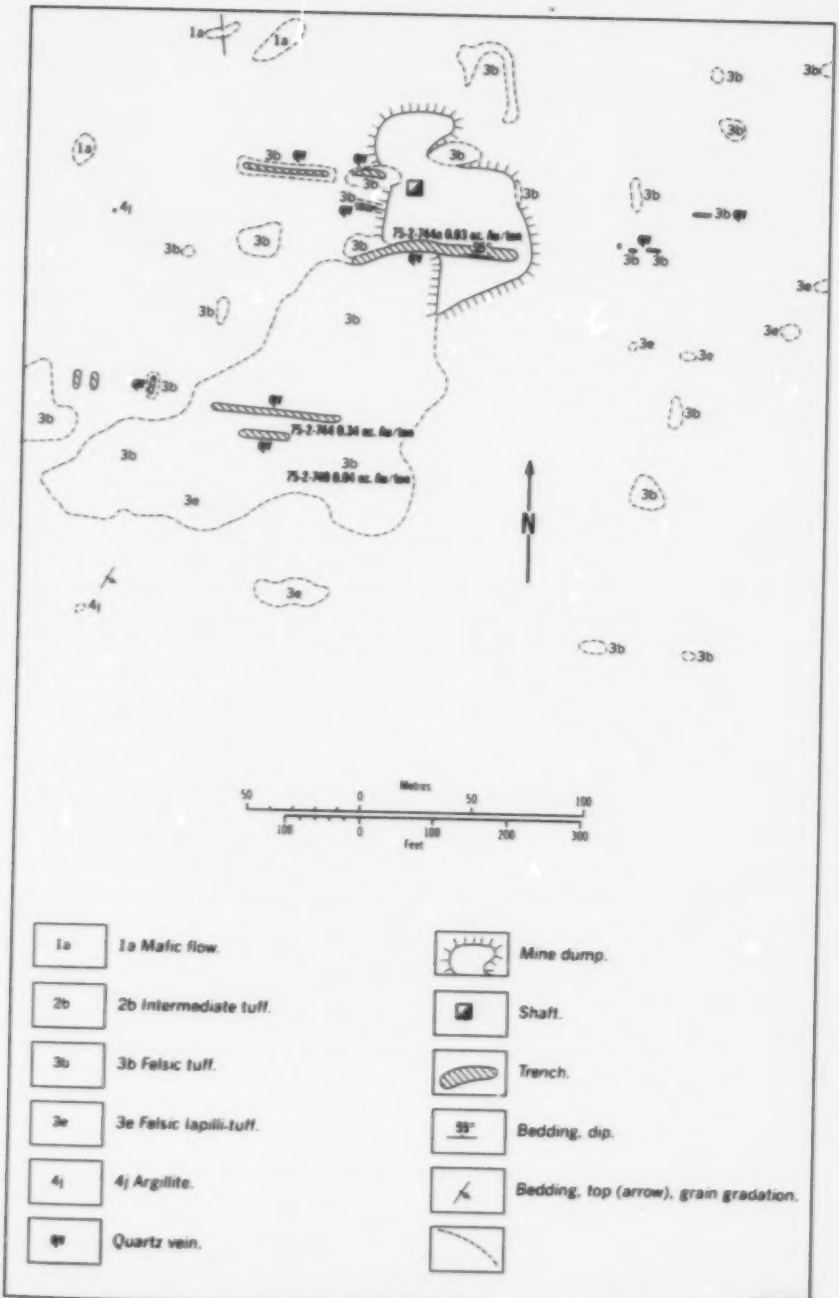


Figure 5–Geological map of the old Sol d'Or Gold Mine. Geological mapping done by R. Falls and C. Ware.

ner of Honeywell Township. Claim Group B, which consisted of six claims, included part of the old Vanco Exploration Dome Group, and Claim Group C, consisting of four claims, was located 800 m east of Washagomis Lake.

The area of Claim Group A is underlain by mafic metavolcanic flows of Volcanic Cycle Four on the west and intermediate tuffs of Volcanic Cycle Three on the east. In 1973, magnetometer and electromagnetic surveys were carried out on the group. Two anomalous zones possibly caused by magnetite and/or pyrrhotite in the mafic flows and intermediate tuff, were defined with the magnetometer survey, but no electromagnetic anomalies were found.

The area of Claim Group B is underlain, predominantly by the mafic metavolcanic flows of Volcanic Cycle Three. In 1973, a 167 m long diamond-drill hole was drilled on a bearing of 270° and a dip of -45°. The diamond-drill hole intersected very fine grained pillowed mafic flows which were cut by fine-grained quartz-carbonate stringers and veinlets. Pyrrhotite with minor pyrite and chalcopyrite was reported to be common between the pillow selvages as stringers and blebs.

The area of Claim Group C is underlain by very fine grained intermediate tuff. Two diamond-drill holes were collared in 1973 on the lake east of Washagomis Lake. The collars straddle the little bay on the southern shore. The length of the two diamond-drill holes totalled 100 m and the holes were drilled in a southeasterly direction at a -45° dip. Both holes intersected fine-grained to very fine grained intermediate tuff, which was slightly bedded in places and minor amounts of lapilli-tuff. The tuff was cut by many hair-like fractures and veinlets of quartz-carbonate material. The veins and veinlets contained cubes of pyrite in amounts that varied from a trace to 10 percent. Minor chalcopyrite was found in some veinlets. The claims were allowed to lapse.

Selco Mining Corporation Limited [1970] (6)

In 1970, Selco Mining Corporation Limited held a group of 18 claims east of, and including part of Sundown Lake. The area of the claim group is underlain by mafic flows, intermediate tuff, the spherulitic flows of Volcanic Cycle Three, and part of the metaconglomerate unit. A single 168 m hole was diamond drilled 100 m east of the halfway point down the eastern shore of Sundown Lake. The rock types intersected by the diamond-drill hole are interbedded, intermediate spherulitic flows, tuff and lapilli-tuff. Irregular stringers and blebs of pyrite and pyrrhotite were found throughout all the rock types. The claims have since reverted to the Crown.

Vanco Explorations Limited (Dome Group) [1970] (7)

The Dome Group of claims consisted of 19 claims; five of them were located outside the map-area. The Dome Group was held by Vanco Explorations Limited in 1970, and was previously owned by Dome Exploration Company (Canada) Limited. The area covered by the Dome Group is underlain, for the most

part, by light green, epidotized, pillowed mafic flows of Volcanic Cycle Three. The western edge of the area is underlain by intermediate pyroclastic breccia.

In 1967, Dome Exploration Company (Canada) Limited, diamond drilled two holes, totalling 165.5 m in length, to test an electromagnetic conductor in the mafic flows. Disseminated pyrrhotite and pyrite with rare flecks of chalcopyrite were the only sulphide minerals encountered through the length of the diamond-drill holes.

In the summer of 1969, Vanco Explorations Limited continued work on the property, and completed a geological survey and ground magnetometer and electromagnetic surveys at a scale of 1:2400. The geological survey within Honeywell Township did not locate indications of mineralization of economic significance. The magnetometer survey indicated that no major areas of the group were underlain by rocks of above average magnetic susceptibility. The electromagnetic survey located two conductors, one of which was caused by disseminated sulphide minerals. In the fall of 1969, a magnetic, electromagnetic, and gamma ray spectrometer airborne geophysical survey was carried out over the claim group. Several conductors were located by this survey, and were checked on the ground in the spring of 1970 by a further electromagnetic survey.

The claims were subsequently allowed to lapse, and no further work has been done by Vanco Explorations Limited.

Vanco Explorations Limited (Sundown Group) [1969] (8)

Vanco Exploration (Ontario) Limited held, in 1969, a group of 34 claims in the west-central part of Honeywell Township, on the eastern arm of Washagomis Lake. The claims are underlain by interbedded, intermediate, massive, and spherulitic flows and tuffs of Volcanic Cycle Three and a wedge of conglomerate. The intermediate flows and tuffs are intruded by small bodies of gabbro and a narrow quartz-feldspar porphyry dike.

Geological, electromagnetic, magnetic, and self potential surveys were carried out on the claim group in the summer of 1969. The anomalies found by the geophysical surveys were reported by the company to have no economic significance. The anomalies were reported to be caused by minor concentrations of magnetite in the intermediate tuffs and flows. The geological survey done by the company in 1969 did not locate any mineralization of economic importance. In the fall of 1969, a magnetic electromagnetic and gamma ray spectrometer airborne geophysical survey was carried out.

The claims were allowed to lapse after this survey was carried out, and no further work has been done by Vanco Explorations Limited.

Cyril Williams [1969] (9)

In 1969, Cyril Williams held five claims along the north boundary line of Honeywell Township, stretching from the McNaughton Township line to the north end of the major unnamed lake, 1070 m west of the west arm of Grace

Lake. Williams carried out stripping, blasting, and trenching on the westernmost claim. A grab sample of crushed quartz taken by the author from a deep water filled pit, 750 m northwest of the island in the west part of Grace Lake, was assayed by the Geoscience Laboratories, Ontario Geological Survey. The sample contained 0.27 ounce of gold per ton and trace amounts of silver. The quartz veins that were pitted and trenched were located in a medium-grained gabbro which has been carbonatized close to the veins. A well-defined trail, starting from behind the cabin on the western shore of Grace Lake, leads to the trench and the location of the pit. The claims have since reverted to the Crown.

RECOMMENDATIONS TO PROSPECTORS

Although no viable mineral deposits have yet been found in Honeywell and McNaughton Townships, the mineral potential remains relatively high because of the existence of the massive sulphide deposit at South Bay in Dent Township, 10 to 13 km to the south.

All the intermediate and felsic pyroclastic rocks should be thoroughly prospected for syngenetic base-metal deposits, with special emphasis on the coarse-grained, proximal facies of the pyroclastic rocks. The upper part of Volcanic Cycle One is an ideal horizon for the deposition of syngenetic massive sulphide bodies. This horizon has a high percentage of coarse-grained intermediate and felsic pyroclastic rocks. According to Sangster (1972, p.3), coarse-grained, felsic pyroclastic rocks were ideal horizons for the deposition of base metals. These rock types occur in the vicinity of Grace Lake. Also, coarse-grained pyroclastic rocks were products of explosive volcanism which necessitated the presence of a high gas pressure in the original magma (Sangster 1972). After the initial explosive activity, the remaining part of the magma started to de-gas. The escaping fluid was an ideal transporting medium for any copper and zinc associated with the magma. The structural complexity of Volcanic Cycle One would allow localization of mineralization in structural traps.

Gold in the Uchi and Red Lake Metavolcanic-Metasedimentary Belts is commonly found in quartz veins occurring in fault zones. The major break that runs from Trout Lake to Springpole Lake is an ideal area to prospect for gold. Gold is known to occur along, and in the vicinity of, the proposed fault zone and the highest assay results of the quartz veins sampled in the map-area were found in the vicinity of the proposed zone. Another known fault zone occurring in a part of the map area is the Swain Lake Fault. The rocks around Swain Lake are highly sheared, contain much disseminated pyrite, and have a potential for important gold-bearing quartz veins.

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MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

All the measurements in this report are given in the units used in the source materials or in the original measuring. If the reader wishes to convert Imperial Units to Metric or SI Units or SI Units to Imperial Units the following multipliers should be used:

Unit	*Multiplied by*	*Gives*	*Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039	inches	1 inch	25.4	mm
1 cm	0.394	inches	1 inch	2.54	cm
1 m	3.281	feet	1 foot	0.3048	m
1 km	0.621	miles (statute)	1 mile (statute)	1.609	km
		AREA			
1 cm^2	0.155	square inches	1 square inch	6.452	cm^2
1 m^2	10.764	square feet	1 square foot	0.093	m^2
1 km^2	0.386	square miles	1 square mile	2.590	km^2
1 m^2	0.000247	acres	1 acre	4046.686	m^2
1 h	2.471	acres	1 acre	0.405	h
		VOLUME			
1 cm^3	0.061	cubic inches	1 cubic inch	16.387	cm^3
1 m^3	35.315	cubic feet	1 cubic foot	0.028	m^3
		CAPACITY			
1 l	1.760	pints	1 pint	0.568	l
1 l	0.880	quarts	1 quart	1.137	l
1 l	0.220	gallons	1 gallon	4.546	l
		MASS			
1 g	0.035	ounces (avdp)	1 ounce (avdp)	28.350	g
1 g	0.032	ounces (troy)	1 ounce (troy)	31.103	g
1 kg	2.205	pounds (avdp)	1 pound (avdp)	0.454	kg
1 kg	0.0011	tons (short)	1 ton (short)	907.185	kg
1 t	1.102	tons (short)	1 ton (short)	0.907	t
1 kg	0.000984	tons (long)	1 ton (long)	1016.047	kg
1 t	0.984	tons (long)	1 ton (long)	1.016	t
		CONCENTRATION			
1 gm/t	0.029	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.292	gm/t
1 gm/t	0.583	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.715	gm/t
1 ounce (troy)/ ton (short)	20.0	pennyweights/ ton (short)	1 pennyweight/ ton (short)	0.05	ounce (troy)/ ton (short)

Suggestion: Although the above conversion factors are given to several decimal places for your convenience, do not attempt to convert an approximate measurement to a precise measurement. For example, "about 1000 feet" should be converted to "about 300 m" rather than "304.8 m".

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